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ABSTRACT

Science and technology are in trouble today. And the world of people and of other living things is in trouble because of them. This seven-part book provides an introduction to the origin and nature of these troubles. Major areas considered in the first six parts are: (1) values; (2) science and technology in an ideal world (examining growth of science and technology, "simple" and "complex" science, research, education, and other topics); (3) science and technology in the real world (discussing negative impacts of technology, delusionary thinking, and other topics); (4) the axioms and process of science (discussing scientific theories and their mortality, Kuhn's structure of scientific revolutions, and other topics); (5) values and scientists (examining tolerance in science and politics, the historical impact of science on values, value-neutrality, and other topics); and (6) science and religion (contrasting science and religion and discussing the historical impact of science on Christianity, the rise and fall of religions, pseudoreligions, and other topics). The seventh part is a summary. A list of references and a list of discussion topics (used in the college course on which this book is based) are also included. (JN)

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VALUES AND SCIENTISTS

John A. White

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John A. White

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Contents

Introduction		vii
1	Values--definitions, examples, degree of commitment, kinds, moral imperative, rational and non-rational thought, Kohlberg's moral growth	1
2	Science and Technology in an Ideal World--growth of science and technology, "simple" and "complex" science, science organizations, research, education, pure and applied science, technologists and technicians, routine science, professionalism, historic achievements	6
3	Science and Technology in the Real World--negative impact of technology, issues, examples, Ellul's Technique, controversy, critical science, perceiving reality in the modern world, delusionary thinking	13
4	The Axioms and Process of Science--facts and opinions, demonstration and persuasion, definitions, axioms and dogma, scientific theories and their mortality; obsoleteness of Euclid; axioms for science, analysis of axioms; explosion of knowledge; scientific method, hypothesis, Kuhn's structure of scientific revolutions, and their non-rational nature, examples, questions about facts	24
5	Values and Scientists--science, truth, and totalitarianism, tolerance in science and politics; historical impact of science on values; value-neutrality; motivations of scientists, fashions, credentialism, great men; Ravetz's ethical basis for science; scientists as activists; Pirsig's romantic and classical awareness, Quality	36
6	Science and Religion: the Legacy of History - science and religion contrasted, demonstrability versus belief; rise and fall of religions, pseudoreligions, parallels between Rome and nowadays; motivations of scientists and the religious compared; historical impact of science on Christianity; science and religion both as authorizations for certainty and action, after Jaynes	49
7	Rationale for Right Action--a summary and epilogue	57
Discussion topics		61
References		68
Index		73

Introduction

Science and technology are in trouble today. And the world of people and of other living things is in trouble because of them. This book attempts to introduce the reader to the origin and nature of the troubles.

It is for two kinds of reader. It is for the person who loves machines, who loves to tinker with car engines, lasers, sophisticated cameras, spectrometers, computers, dialysis machines; who loves instruments for their power of solving human problems, doing routine work, and revealing the secrets of nature; who has a passion for scientific research. It is also for readers whose background or training may be in business or the arts and crafts.

Because of the nature of the problems, it is increasingly necessary today that all levels of scientists, technologists and technicians be sensitively aware of the moral aspects of their work. The non-scientists need to be just as aware, because they often work for or with scientists or hire them, and because of the increasing technical sophistication of traditionally non-technical activities like business or art. Consider the impact of computers on accounting, the complexities of modern off-set printing.

The relation of values to science is the area where the different interests of these people meet, as do those of philosophers and humanists also. The aim then is to foster dialog, earnest discussion among all of us, in the belief that this is the best way to define and to solve the problem of the troubles. If this aim be achieved even a little, then it will be the better for the healthy functioning of democracy too, because many political issues today have both technical and ethical aspects.

To explore this subject we must do three things. First we must think about values, a topic largely outside the domain of science, which turns out to be the key to the troubles. Then we must consider exactly what science is and technology is. Then we must see how to put them together with values in such a way as to provide a "rationale for right action." This phrase is something of a contradiction in terms, as it turns out that right action is seldom rationally determined. But the contradiction exactly encapsulates the problem with which we have to deal. All of us. There is no escaping it, because that is the nature of human existence in the twentieth century.

I am indebted to many students, friends, and colleagues for ideas, advice, and inspiration, particularly G.E.D. Brady, Dane R. Gordon, Edwin O. Hennick, and V.V. Raman. I thank them, and Joan S. Green for help with the films; Stefanie Barley and Computype of Rochester, NY, who typed different versions of the manuscript; and the Editorial Staff of University Press of America, who kindly commented on it.

I am more than indebted to Janet and to Katie and Tom for more than the usual measure of forebearance customarily allotted to authors of books by their families.

"Values and Scientists" is dedicated to all my family and in loving memory of my father, Eric Wilfrid White, 1903-74, who was a poet. Also, more generally, it is dedicated to the young, who are the future.

Values

How do you react to the thought of people who hide razor blades in apples to give to unsuspecting children? Most of us recoil in horror, because we believe human life and good health to be rights, and that children deserve special protection. These are values, examples of what dictionaries and encyclopedias define as things we hold to be right, or just, or beautiful. Values are things to which we have emotional commitment, things about which we have strong feelings. The particular values which operate in the case of the razor blades are widely held. They have been continuously upheld in many societies for millenia by precept, education, and of course law. They are not universal. Part of the training of combat soldiers is to inculcate the idea that it is sometimes right to kill and maim. The arduous nature of this training reflects, though, the tenacity with which the dominant value of life is held.

There are thus degrees of commitment to values. The well trained soldier will probably still believe in life and health, but have a stronger belief in defending freedom, or the fatherland, or even his own life rather than the enemy's, or yet again, his comrade's life rather than his own.

The questions of life and health is fundamental to us. Many things excite feelings of a more complex sort which are not fundamental to existence. Consider the statement that passenger train service may shortly end forever. Some react favorably, some unfavorably, some show little interest. Those in favor may hold any or all of these values: thrift (in the U.S. the Amtrak system costs taxpayers hundreds of millions a year: both labor unions and high executives are felt to sap too much of the financial resources); progress (trains are old-fashioned); efficiency (other modes of travel are considered more amenable to modern methods of management and maintenance, or are simply faster, or offer door-to-door convenience); environmental preservation (steam and diesel engines pollute the air). Those not in favor will hold different values, such as efficiency (this time interpreted as the number of passenger-miles per gallon of fuel); nostalgia (trains were beautiful in at least two ways: the impressive presence of the steam locomotive in sight and sound, and years ago the connotations of a life of opulence and leisure); environmental preservation (caused by negative reaction to highway building and car-related air pollution); high employment.

Many of our opinions are of course based on erroneous or incomplete information as is shown by these reactions. For

example, trains cannot waste and conserve energy at the same time. Indeed some of our most strongly held opinions are those based on the least information. We even tend to compensate for ignorance by expressing strong feeling, maybe to scare off opposition. Unfortunate as this may be, there is no easy solution. One may expect people to read exhaustively on the complex problem of the trains before they speak or write, and some do. Those charged with decision-making responsibility, the railroad executives and the Congressmen who allocate the money, will have to know the subject well. Those who hold smoothly running democracy to be a value will also expect the voters to be informed about political issues. Passenger trains have been a public issue for years, simply because persuasive arguments can be and have been constructed on both sides, and large numbers of people are involved.

There are more pressing issues. There are others whose values are such that they are little concerned about trains.

Webster's Dictionary provides thirteen meanings to the noun value, and three to the verb.[11] Among the thirteen, value can mean "that quality of a thing according to which it is thought of as being more or less desirable, useful, estimable, important, etc ; worth or degree of worth; that which is desirable or worthy of esteem for its own sake." It is useful to distinguish intrinsic value which is worthy entirely for its own sake, such as human life; and extrinsic value which is worthy because it is useful, such as high employment above. This value in turn depends on more fundamental values such as quality of life and health. In the plural, values can mean "the social principles, goals, or standards held or accepted by an individual, class, society, etc." So values can be a group thing as well as an individual thing. As we shall see, one of the problems of all societies is that individual and group values do not necessarily coincide. An individual can only pursue and uphold some group values at the expense of his freedom, often a strongly held individual value.

There are also absolute and relative aspects to value. We may say life is an absolute value, meaning that life is to be protected, promoted, improved at all costs, without concern for other conflicting values, such as patriotism. Such is the stand of the conscientious objector. On the other hand we may say that something has more value than some other thing and less than a third thing. Absolute and relative value are not the same as intrinsic and extrinsic value.

There are other ways of shedding light on what we mean by value, by distinguishing other more subtle aspects, each the

object of one or other philosophical theory.[12] There was a time when value had a more concrete economic meaning, still used in phrases like cash value. However, in the nineteenth century, there was a rediscovery of Plato's idea that questions of good, right, obligation, virtue, beauty, truth, and validity all belong to one family. All are concerned with what ought to be: not with what is, or was, or will be. The meaning of value thus expanded, first within academic circles, and later in ordinary discourse.

The words moral and ethical cover some of the meanings of the word value. Perhaps we should note there is less overlap with the adjective valuable. Moral, according to Webster,[11] means among other things "capable of making the distinction between right from wrong in conduct, relating to the principles of right or wrong, good or right in conduct or character, in conformity with the generally accepted standards of goodness or rightness in conduct or character." We note the group significance of the term "generally accepted standards". Ethical means "conforming to the standards of conduct of a given profession or group," emphasizing the group nature even more. Indeed conduct in one profession need not apply to another, and is a matter for deliberate agreement among the particular professionals. Thus, such ethics need not be universal, nor of much concern to individuals or groups outside the profession. Morals are more universal. But they do not cover esthetic value: that which is held to be beautiful, such as mountain views or music.

There is no moral imperative. That is to say, there is no way of absolutely enforcing any morality. Morality and social values can be instilled by example, precept, education, religion; self-education from experience; legislation; even armed might. But the process must remain an imperfect one, because our individual values do differ. The injunction to refrain from murder is widely observed, is supported by precept and centuries of law, and is enshrined in the Ten Commandments. Yet murder continues to happen, and is unpreventable, because an individual for whatever reason holds such values as material gain or revenge more strongly than preservation of life. Occasionally social values differ too. Just after the First World War, temperance was a value so widely held that it became a political issue in this country, to the extraordinary extent that the Constitution was amended to prohibit the sale of liquor by law. Extraordinary, because elsewhere this has only happened in Finland, Iceland, and Russia.

However, other sectors of the population soon found ways to both manufacture and consume liquor, and public sentiment was such that Prohibition became unenforceable. The abuse of both

law and alcohol grew to the extent that there was clearly more liability than benefit in Prohibition, and in 1933 the amendment was repealed. The same sort of change may happen with marijuana.

The Prohibition issue illustrates well another aspect of values, their necessarily non-rational nature. The arguments against drinking, especially against drunkenness and alcoholism are unanswerable. The social damage and even more the individual damage are a tragedy and a curse. But the use of an emotional word like curse reveals an emotional commitment which goes beyond rational arguments: the statistics, costs to the victims and to the public. However, the impressiveness of the data means that the case for Prohibition is firmly based on rational considerations, by which is meant due recognition of cause and effect. The case against Prohibition is much less rational, including such personal matters as taste, liquor as a "social vehicle," as an escape from problems and tension, as a sort of puberty rite among the young. Clearly, it was these things which appealed more to the American public in the end.

Values then are linked to feelings rather than rational thought on both sides of this issue, and any issue. Simon has said that a true value must be prized and cherished, freely chosen from among alternatives after due reflection, publicly affirmed and acted upon repeatedly.[13] This might be true ideally, but few of us reflect on our feelings, and some of us may well hesitate to declare something we feel but cannot easily justify.

The non-rational nature of values is hard to accept and to come to terms with in this technologically dominated century. Science and technology are our most rational activities, and their dominance in all aspects of modern life demonstrates rationality itself as a deeply held value in Western Society. This was not always so. To medieval or Renaissance man, rationality was not nearly so important. So we may reflect on the paradox that while nowadays we believe deeply in rationality, that very commitment is itself non-rational, emotional, esthetic, perhaps religious.

Lastly a word on how we acquire values. Some of us do so consciously through instruction in church-related schools, some unconsciously from the society around us, parents, neighbors, friends. Lawrence Kohlberg distinguishes three broad levels in moral development, termed preconventional, conventional and postconventional, and each with two stages.[14] We begin by being restrained from immoral acts not by moral awareness, but the threat of punishment, and grow into observing fairness and

reciprocity not as a matter of principle but in a pragmatic, ad hoc manner. At the conventional (adult) level, we are loyal to the expectations of our family or nation, hoping in return for approval as a reward; and then learn to value authority, law and order. Perhaps twenty percent of us move on to the post-conventional level when we perceive both the value of law and also the limitations it places on personal freedom; and much fewer of us in progress to the highest stage, where conscience determines what is right on the basis of principles one chooses as applying to all mankind. At this stage we have the true conscientious objector who chooses the universal value of life over the more limited value of patriotism, and may break the law to follow the profounder good. Kohlberg finds these stages to be universal among several societies studied. One reaches one's own highest stage without missing any lower stage, and without either comprehending or accepting any higher stage.

Science and Technology in an Ideal World

One of the most fascinating aspects of science and technology is that they are living organisms. They were born in the past, have grown, especially in this century, and eventually may grow old and die.

The growth is obvious, in the increasing numbers of people employed, in the increasing public and private expenditure, in the increasing way technological artifacts--everything from cars to electric toothbrushes--have intruded into our lives--and mostly with our enthusiastic approval; the increasing number of articles published in professional scientific and technological journals. In 1980 the Chemical Abstracts Service of the American Chemical Society published abstracts (fifty-word summaries) of 476,000 articles published world-wide in the field of chemistry alone. The number has doubled five times since Chemical Abstracts began in 1907.[15]

It is helpful in understanding this growth to distinguish between simple and complex science and technology. The difference is historical. By "simple" is meant production of steel and other metals, simple electrical machines, the machine gun, manufacture of gasoline, steam engines, the composition of air, all the inventions of Thomas Edison. By "complex" is meant space exploration, computers, nuclear weapons and power, a cure for cancer. Simple science and technology ruled the Western World from the Industrial Revolution until very roughly 1920, and was dominated by individuals who were often individualists: Faraday, Watt, Steinmetz, Nobel, Brunel, Edison himself. Before the early part of the nineteenth century science and technology were separate. Science was pursued by academic enthusiasts (Newton, Leibniz, Dalton), by some as a hobby (Franklin). Technology was pursued by inventors, some with little academic training, and with little urge towards discovery of new knowledge for its own sake alone (Newcomen, Bessemer, and again Edison). "Complex" science and "complex" technology are inseparable. They are characterized by organizations and professionalism, by many relatively anonymous workers in many places, communicating via their professional literature and at professional meetings, by planned research, by huge expenditures.

Society interacts with science and technology, that is, creates them, pays for them, learns and disseminates them, employs and

is employed by them, and buys and sells them, through such organizations as industries, businesses, government laboratories, academic and professional societies, lobbies, and universities.

Industries are dependent on technology for the efficiency with which they produce their artifacts, and on scientific research for ways to improve continuously this efficiency, so as to stay abreast of the competition. Some businesses thrive by providing specialized scientific or technical services, either research or routine measuring and testing, rather than producing an artifact for a product.

All such industries depend on demand. If demand goes down seriously, the industry must tighten its belt, change its business, or go out of business. However, demand can be artificially manipulated by government decree, at any rate for a limited time, and this is now the rule rather than the exception, especially in major industries like steel, fossil fuels, and especially in industries depending on military orders. The troubled history of Lockheed Corporation is an illustration. When government contracts for heavy military aircraft dry up, there is a danger of bankruptcy, and wholesale layoffs. The demand for military artifacts in peacetime is of course highly artificial, a matter for strategic judgment in the Department of Defense. And this judgment is subject to unpredictable changes in the international situation, and to some extent the influence of lobbyists. Of course Lockheed's difficulties are no reflection on the excellence of its products. However, we will see later that there may be some relationship here.

The larger industries maintain not only applied research departments, which conduct the search for new ways and means directly related to the product, but conduct pure research as well. That is, scientist-technologists are hired to pursue projects of an academic nature which have some relation to the product, but the yield of efficiency-boosting new knowledge or expertise is hoped for rather than expected. In a lean year pure research may be the first activity to suffer cuts. Yet this may be short-sighted as all the great breakthroughs resulted from pure research, such as Teflon at the DuPont Corporation, and earlier, polyethylene at Imperial Chemical Industries.

The government is also deeply involved with science and technology. If expenditure on research and development is a measure of this, then the U.S. Government is not only the biggest spender ($17 billion in 1969), but spends more than all of private industry ($11 billion).[16] This is one of several indicators that we don't have the private enterprise economy many of us believe or wish for.

The government not only funds research and development in industry and universities, but operates its own research establishments and manufacturing operations, such as at Oak Ridge, Brookhaven and Argonne. Funding for such operations is dependent on decisions made in the White House and by the Congress, often on a year to year basis, and the decisions are made on expert advice, with greater or less influence from the lobbyists in Washington.

The lobbyists, whether the Manufacturers Association, representing industrial interests, or Ralph Nader, representing consumer interests, also deal in science and technology. Any effect they have in promoting them, however, is incidental: their purpose is to procure decisions and legislation favorable to their clients.

Another way science and technology impact the public is through academic and professional societies. Academic societies are nonprofit making, and exist to disseminate knowledge, to promote science, publish journals, hold meetings where scientists communicate, and lobby for legislation to further their purposes. An example is the American Chemical Society.[17] In 1982 it had 128,000 members, some academic but most industrial. It ran four national and eight regional meetings, the principal business of which was presentation of new research results. The Society publishes twenty-two journals, offers video and computer courses, operates student affiliates, runs careers services and an employment exchange for members, also a pension plan, and develops public and international relations. One of the lobbying efforts was a toxic waste disposal plan presented to the Environmental Protection Agency. Another was an attempt to get more government money into science education.

The welfare of members appears to be a rather minor part of its activities. Professional societies such as the American Medical Association are more member-oriented. A more extreme example is the American Association of University Professors.[18] While it is not primarily a science or technology promoter, many of its 9,000 members are professionals in these fields. Its prime object is the welfare of members, and the maintenance of ethical standards in matters of hiring and firing and other aspects of university governance. In recent years, with much trepidation and soul-searching from some members, it has promoted collective bargaining, and has thus become a union. It also holds an annual national meeting and several regional ones.

The importance and sophistication of science and technology in our society mean that there is an unprecedented effort necessary to educate and train people to become scientists and technologists. The responsibility for this falls mainly on the universities. The growth of science and technology have had an impact here as well, on the number, size, wealth, and importance of universities, and on the curriculum too.

The contemporary form of degree programs is distinguished by: the wide choice of major subjects; minors or service courses in related areas; and more or less "liberal arts" courses, again chosen largely by the student from an enormous range of subjects at many levels of prerequisite skill or knowledge, courses which present their content with varying degrees of rigor. Science and technology play a large part, under the familiar headings of chemistry, biology, electronics, mechanical engineering, computer systems, and so on. This format did not begin suddenly, but it is very roughly only a hundred years old.

It should be made clear that science always has been a part of education, but in the fifteen centuries prior to the last century, its role was very different, and the purpose of education was fundamentally different too.

Higher education today is job-oriented. Technological society requires us to be highly trained if we are to compete successfully in the job market. A very new feature, caused by the accelerating pace of technological development is the need for periodic retraining. There have traditionally been more jobs for those with science or engineering degrees than for arts and humanities graduates although this is not the case some years.

In earlier centuries one went to college not to learn a trade, but to learn the arts of appreciating, understanding, and knowing the truth, and thus become an autonomous, mature human being. This is what the liberal arts originally were, "liberal" meaning liberating one from ignorance. To these ends one studied the classical languages, Greek and Latin, and the great books of western civilization. Why? Because truth is not easily accessible to any of us, and studying mankind's greatest writers on fundamental questions is the best way to approach it.[19]

These two philosophies of education are so profoundly different, it is next to impossible to compare them. However, the modern format has been attacked from time to time, and there have been various attempts to reinstate the older way. The most famous is the Program of St. John's College, Annapolis and Santa Fe, which has run the last fifty years.

At this point we will move closer to the scientist and technologist, into their working environment to analyze what they do. The pure scientist searches for new knowledge for its own sake: new relationships, new laws, new data about nature--for their intrinsic interest in relation to what is already known. Only he determines what is of interest. Once politicians, manufacturers or environmentalists take an interest, the science becomes "applied." The applied scientist searches for new knowledge for ends definable in non-scientific terms. Weapons systems, synthetic leather, clean air, a cure for cancer all need, generate, and use new knowledge, not for the intrinsic interest of that knowledge, but for the extrinsic ends of waging war, making a profit, preserving life, or whatever. The dividing line between pure and applied science is not sharp. Many borderline scientists move easily from one to the other several times in their lives.

Technologists do not seek new knowledge per se. They design machines, instruments, systems and organizations as means to ends. The ends may be clearly scientific, such as measurement of trace pollutants, or clearly non-scientific, such as promotion of human profit or power. Technology is telephones, clocks, computers, typewriters, electric toothbrushes, the antiballistic weapons system, fountain pens. It is also more than mere artifacts such as these. Jacques Ellul in "The Technological Society" has shown the concept of technology to be much broader, to encompass such matters as law and even primitive magic. After all, these too are human creations, devised as means to ends.[1]

The function of the technician is to be distinguished from that of the technologist: He runs the machines and instruments. He does not consider himself responsible for their design, except in limited ways. More importantly, he may not consider himself responsible for the uses made by others of the data, artifacts, or materials he generates. As we shall see, this is a difficult modern problem.

Related to both of these functions is that of the technocrat, who administers and manages technology, and is concerned with all aspects of government activity in this area. Again the dividing lines between the functions of technicians, technologists, technocrats, and pure and applied scientists are not sharp, and individuals may wear two hats.

Science and technology may also be analysed into research and routine functions. Research is the planned search for new knowledge. The researcher is intimately familiar with publication in his field, that is, with similar research going on elsewhere. With this in mind, and his own ideas of where progress ought to go, he plans and designs experiments which will yield the new

knowledge. Normally there will be some aspect of this work which is entirely new.

Routine science and technology are: testing alloys for tensile strength, waste water for pollutants, blood for albumin. Here the data are new and valuable, but they do not add significantly to our understanding of nature. Once again, though, there is the indistinct dividing line. Most research requires routine measurements, and these may turn out to have unforeseen interest, suggesting further research. The technician who has a mature understanding of his techniques may also be the one to perceive this.

Without meaning to confuse the meanings of research and routine work, we may note in a larger sense the routine nature of research in this society. It is easy to take for granted the enormous power over nature which we have when we apply to the vice president of development for funding, or to the government, explaining that the planned experiments will cost so much, need so much technical assistance, and yield results within a specified time. Of course, these projections are sometimes wrong, and some always will be, but they are right enough of the time for administrators to allocate the funds with confidence.

The administration of science and technology is a demanding profession in itself, requiring knowledge of, and ideally experience in the projects administered, and in addition the expertise in accounting and personnel management necessary to be ultimately responsible for these matters. Many scientists become administrators, although the academic ones usually regret the time lost from research work.

The difference between researcher and technician also shows up in the way they are trained and hired. The researcher has higher formal degrees and is hired at a salary with expectations of unlimited advancement. The technician is hired by the hour, and the pay is commonly thought to be a bigger part of his "job satisfaction," than in the case of researchers. In short, the researcher is a professional.

It is therefore necessary to consider what the professional professes. What further attributes set him apart from others? In addition to more advanced training and a salary, he may be independent enough to set his own working hours and charge a fee. He will probably be concerned with some aspects of policy and administration even if he does not consider himself an administrator. He will exercise these concerns democratically, through a system of committees rather than interaction with a boss. He may be politically more organized than the non-professional--not in grass roots local matters, but in matters pertaining to the profession. He is status conscious, a hard

worker, is motivated, is competitive. He may also see his work as a service to humanity, a feature which distinguishes the science-technology professional from professional footballers or bridge players. He supports a system of professional ethics. As we shall see, the scientist-technologist is bound to the ethic of honesty more than, say, lawyers, stockbrokers, or politicians, not so much by professional agreement or law, but by the custom of the practice of the profession. No scientific research can succeed unless it is based upon previous work which is reliable.

To summarize, this chapter has outlined how science and technology have changed in the last century, some social organizations through which they impact us, their effect in education, the different kinds of science and technology, and the need for professionalism.

One could go on by describing one or other of the great events in scientific or technical growth, such as the invention during the First World War of the Fritz-Haber Process for the fixation of nitrogen, which enabled the air to be used as a raw material for the manufacture of explosives. Or it could be the discovery of polyethylene or teflon, together with the startup of manufacture and marketing, and consequent effect on our standard of living. One could relate the spread of the electric power grid. One could go back further and describe the finishing of the Brooklyn Bridge or the completion of the transcontinental railroad, events which caused great public pride and were attended by booming cannon and gaily festive crowds.[20] The space shots still have this effect.

It is this picture of pride and delight, which goes back so many generations, which is the cause of our trust in this kind of activity as a blessing to humanity, giving us ever increasing prosperity, profit, power in the world, and leisure time.

Even without the success stories, the account of the science organizations is likely to leave us with a glow over the momentum and accomplishment.

However, the description is not a true one, because it is not complete. That is why the world of this chapter is called an ideal one. It has become the world of science and technology as we wish it were.

Science and Technology in the Real World

So far we have described an ideal modern world, one where science and technology are unassailed benefits to humanity, where its practitioners have an honored and respected place pushing back the frontiers of knowledge and solving mankind's problems.

Yet we all know this is not realistic, not a complete picture. The scientists themselves know it, the politicians do, the Hippie Generation knows it, and in a less articulate way, so does the general public. The film "But is this Progress?", originally a TV documentary in 1973, describes the reactions of three different generations of Americans, and how their lifestyles have changed, and what their values are.[21] There is an elderly couple, married nearly sixty years, nostalgic for the quiet beauty of remembered landscapes before the coming of expressways and suburbia, valuing tradition and self-reliance (from the days before Social Security), honesty, hard work, and their understanding of technical progress. There is a couple nearly fifty, who are mobile and professionally successful, valuing success, education for their children, technology over manual labor, security. Family is of great importance to both couples, but not to the last interviewee, a woman of twenty-seven, divorced and not wanting children, who does not value status, education, or technology, is indifferent to her work as a programmer, and likes to escape to a fairyland world of nostalgia for the old days--home cooking, amateur music, horseriding. It should be emphasized that none of these very ordinary people are strongly against science and technology--not so much anyway as are the film editors, who for instance give a very negative picture of the dozen odd house moves the middle-aged couple made and themselves approved of. However, this thoughtful film does provide a true picture of public concern over science and technology; of people addressing the question, "But is this Progress?" Today's twenty-year-old might not identify with any of these three ages and stages, and yet have the same concerns.

The literature of the last decade though abounds with much more articulate and trenchant accounts of the negative impact of science and technology on society. Here are some of the effects, in an unlucky list of thirteen. The word perceived is meant to suggest that these things are issues: they are not agreed upon.

> Individuals committing immoral, sometimes criminal acts with diminished responsibility, because of their relationship to an organization which provides a climate conducive to such acts, even if not actively promoting them

The perceived erosion of freedom in response to the need for military-industrial efficiency
The perceived lack of fulfillment in the lives of ordinary people
The perceived ugliness of the products of technology
The perceived superfluousness of the young
Pollution of the environment and depletion of resources
Political decisions and legal remedies which create or worsen problems
Academics doing research on Department of Defense contracts
The publish or perish syndrome
Ethical problems in the life sciences associated with contraception, abortion, euthanasia, malpractice, genetic engineering, and the inhuman bureaucracy of some modern hospitals
The explosion of knowledge
Widespread interest in astrology and the occult
Doomsday problems like the population explosion, nuclear war, and bacteriological war

Some of these things we will consider, in this and later chapters.

In 1971 at the height of the movement to end the Viet-Nam War, Charles Reich wrote an article, "The Limits of Duty," pointing out the inadequacy of the criminal code to deal with events of that time.[22] In the attempt to control a Washington demonstration, motorized police and bus drivers drove directly into the crowd, in the steadfast belief that they were doing their duty. Had deaths occurred, would such individuals have been guilty of murder? Shortly before this, Lieutenant Calley was accused of causing the deaths of several score civilians in Viet Nam, in what came to be known as the My Lai Massacre. Was he guilty? Solely guilty? The President of the United States commuted the sentence of his Court Martial. In the matter of the use of napalm (a gelatinous substance which burns, causing grievous injury--again at that time to Vietnamese civilians), who is responsible: the aircrew of the aircraft dropping it, the commander ordering the raid, the general, the Pentagon, the chemists who made it, their administrators, the President, Congress, the public who elected them? Reich says all are guilty, because centuries of the use of Common Law require it, and he gives several examples. Common Law is based on standards of conduct demanding individual responsibility. This is an ideal, unfair maybe in some cases like Calley's, unattainable in others, one which requires an exalted view of man's capabilities. In justification, Reich quotes a nineteenth century English judge who said: "It is enough in a Christian country to remind ourselves of the Great Example whom we profess to follow."

However, what has happened in the last century is that organizations, necessary creations for the pursuit of technology, have grown up, and they have the function of sheltering the individual from personal responsibility. The higher value is loyalty to the organization. Thus there arises a social ethic in which the individual is discouraged from observing Kohlberg's post-conventional level of moral awareness.

Several writers have called for the restructuring of the law to pin responsibility on organizations, to protect and encourage individuals who take stands against abuses, who "blow whistles."

The film "Enemy of the People" relates the incident of a manager at a Lockheed plant in the South building a large transport plane, who says he discovered parts being recorded as installed in the plane, but not installed in fact.[23] He researched and documented this abuse, and senior administrators read and listened, but did nothing. Because the funding for the plane was public, he next informed members of Congress, with similar results. After that he told the media, who printed his story, causing a great ruckus in the home town. It so happened that the plant had just lost a contract, resulting in massive layoffs, we must assume for reasons not connected with his activities. However, colleagues and neighbors began to shun him and threaten his family, and in the end he was forced to resign. To be fair, the film also reports eloquent testimony from a former mayor, who thought he was doing the right thing. Officials branded him as a rabble-rouser after publicity, but the film portrays him as a folksy, church-going, family man with a simple zeal for doing right. It is perhaps not possible to decide the truth here without further information.

There have been other similar stories of whistle-blowers, from industry, the army, and the government. All are examples of the conflict between individual morality and group ethics. This is not new. This film was named after a nineteenth century play by Henrik Ibsen on a similar subject.

Scientists are also aware of the special difficulties of individuals. Hoyle the astronomer, in a lecture given in 1960 on this topic, said there is no such thing as an individual totally divorced from society: such a person would not even have developed the use of language.[24] The social environment has already been of more importance to an "individual's" future progress and productivity by the age of ten, than is his own talent. Both factors must be good for extraordinary flowering to occur. However, the rapid advance of technology has put a strain on our social adaptability, leading to a world-wide feeling of strain or tension. There is no solution offered in any current political system. Our upbringing tends to emphasize individual rights, with its religious values and democratic traditions. On

the whole, non-individualist upbringing has little appeal. Hoyle says we are drunk on technology, and have yet to learn any kind of moderation.

On the lack of fulfillment in the lives of ordinary people, it is enough to cite soaring rates of crime, depression, suicide, child abuse, divorce, alcoholism and abuse of drugs. Of course, none of these is new, and soaring rates may reflect greater accuracy in reporting rather than in incidence of some of these problems. Clearly though they are not decreasing. Some are at epidemic proportions. One of the most telling criticisms of the NASA moon landings a decade ago was that our resources would be better directed towards the humane ends of addressing these problems rather than space research. This is despite the possible benefits of this research.

It was suggested that technical products are ugly. This is not an opinion which would be shared by those who admire computers or modern architecture, nor by steam locomotive fans. Nor will it be shared by those whose business is marketing, whose instincts are guided by what one might call a democracy of taste, for whom the packaged merchandise must appeal to the greatest number, and not therefore promote any exclusiveness, any sense of improvement in standards in esthetic values, nor any satisfaction of that deep human yearning for growth in discriminating power.

One clue to our real feelings about the esthetic attractions of technical products is the price of old art and craftwork. There is something compulsive about the way we treasure old masters, the Raphaels, Rembrandts, Renoirs, and more recently, Picassos, paying sometimes several million for a single item. Leonardo's Mona Lisa can now be said to be priceless. There is something absurd, even obscene in such high figures. This is not to be confused with an artist's right to be decently paid for his work, a right which Renoir insisted on (and said was the artist's only right).[25] Then there is the Chippendale furniture, the Ming porcelain, Roman glass, the objects from Tutankhamen's tomb. Then again there is the architecture, the medieval mansions, cathedrals, castles. One might add the classical music.

This veneration for things past is admirable in some respects: it is an essential part of our culture. But there seems to be an over-reaction. For one thing, such veneration is rather new. Until this century the great works of the past simply became

unfashionable. But now everything is fashionable, even the beads and masks of primitive tribes, the broken pots of prehistoric man. Why? Could it be that the ubiquitous technology is meaningless to the human spirit? We seem to have lost not so much the talent for creating such art, as the motivation for it. Our values have declined. Perhaps we spend so much on it to remind ourselves our forefathers could be moved by esthetic and religious impulse to thus express themselves, in a way we cannot. Thus we try to save something from the wreck.

At this point we have listed some frightening problems, shown individuals at odds with society in various ways, and given evidence for a pervasive sense of something lost. It is harder to demonstrate the connection between all this and the professional scientist-technologist honestly and laboriously designing artifacts, or even organizations trying to make life richer, better informed, or more leisured. This is what Ellul has done in "The Technological Society".[1] To Ellul, science has become enslaved by technology, and so his treatment is comprehensive, science being part of the whole. However, it is also true that science is technology's cutting edge. It is the frontier across which technology advances. So we first consider technology, and the part that science plays in creating or aggravating our problems will come later, indeed, when we come to consider Values and Scientists.

Ellul's book is a searching analysis of what technique (as the translator calls it) is, as well as what it does. As was said earlier, it is an ensemble of machines, instruments, systems, and organizations in all human activities, designed as means to ends. The ends are above all economic efficiency. So the means become, as time goes on, more perfect, more productive, more competitive to this end. Thus there comes to be only one legitimate way to do anything, the most efficient way, and there must be increasing efforts to make it still more efficient. In these increasing efforts, the means and ends become confused. That is to say, the means become the ends. Efficiency as a value begins to dominate just those other values, richness in life, more individuality, more leisure, the technologist thinks he is promoting. Thus we promote competitiveness as a human activity above all other activities.

Ellul portrays technique as a dynamically progressing thing, a monster beyond human control. It develops throughout the world according to its inner logic almost without human intervention,

promoting behavior (conformism), political structures (totalitarianism), mental processes (rationality, to the exclusion of art, individual creativity) conducive to efficiency. Technique is opposed to nature or absorbs it for its own ends.

Some examples will make these ideas clear. A bulldozer and a computer can replace the muscles and brains of a hundred men in the tasks they are designed to do. For a century we have imagined the benefits--the energies released for leisure use, or at any rate for pursuits more rewarding than manual labor and routine calculation. The reality is different. The machines do not release us, they replace us, and to stay employed we must learn to drive or to program, and do it well enough to compete with the ninety-nine men now unemployed, or else to service these machines in the same competitive context. Technique has thus forced us to spend our resources--in money and mental effort--to compete in life, where before we could compete without these expenditures. Maybe one in ten of the workforce is unemployed at any one time, and much higher percentages of uneducated people, racial subgroups, and the young.

So the end result is that technology has cut costs and increased the competitiveness of a few people, and at the same time burdened them with a bigger welfare bill to enable the unemployed to live. This might seem a fair exchange, if all parties agreed to it. But the unemployed hate welfare because of intrusive bureaucracy. More importantly, noone likes to be unemployed. To Ellul, work is the way we all realize our potential, achieve our dreams, become truly human. The right to work should therefore be an absolute value. Leisure activities substitute in too many individual cases. But if something is really worth giving our time to, then we should be paid for it, as a right and not a privilege.

The threat of unemployment looms over our lives like the sword of Damocles, hung over his head by a single hair by the tyrant Dionysius, to teach him the nature of a monarch's life. No wonder the worker is sometimes trapped into unethical conduct, into making napalm, burying toxic waste, making plutonium warheads, and threatening the lives of whistle-blowers.

Public opinion polls are a technique. Whatever information they may gather, and however it be used, they serve the purpose of discounting minority dissenting opinion. A single opinion, no matter how cogent, or articulately expressed, has no place in the poll except for the statistical count of one, and therefore fails to get publicized. Thus technique is opposed to individual expression, and therefore freedom.

Publicity itself is also technical. All the media, television, film, newspapers, depend on high technology, and are thus

centralized. Dissenting opinion is often discouraged, or presented as entertainment, and therefore not to be seriously considered.

The enslavement of the individual scientist by technique is shown by the fact that scientific research now needs great technical sophistication, and often cannot progress until an appropriate technical breakthrough has occurred. Then the breakthroughs demand more science, as their justification, and so on.

Technical efficiency in the economy requires planning. Thus the government is required to intervene more and more in the free market. Thus government grows and the economy becomes more centralized.

Since technique recognizes only one way in government, the most efficient way, and tends to stifle dissent, technique is fundamentally opposed to democratic institutions. The Communist System frankly embraces technique, and so did the Nazis. Insofar as there is or was social unrest under these systems, the technique was not perfect. Technique requires man to be not only subservient, but also contented with his lot, in the interests of course of greater efficiency. This has not yet happened, and hopefully never will. Such an eventuality, though, has been imagined in Aldous Huxley's famous novel "Brave New World."[28]

Technologists are often criticized on the ground that they live by the philosophy: "if we can, we should." If we can build atomic bombs we should use them. If we are on the threshold of conducting genetic engineering, we should conduct it. If we can eliminate disease, we should do so. These are "doomsday problems." We should use atomic bombs only because if we don't, they (the fancied enemy) will use them on us. Yet should they be used in an all-out war, it follows, and there is no escape from this, that billions may die, and the world will never be the same again. The results of unrestricted genetic engineering research may be just as catastrophic. The statement about disease is at first sight less problematic. But since the rise of sanitation and medical technology have caused the world's population to increase at a rate greater than exponential (the doubling time is now thirty-seven years and decreasing), then the consequences are again catastrophic.

Thus the dictum "if we can, we should" will not stand up to analysis. Yet in all cases it is supported by strongly held values. The absolute value of technology is efficiency, and that requires "if we can, we must."

Hence the pursuit of technology has placed us all in a world of an unbearably threatening nature. There is absolutely no solution visible to these problems. Yet if we value life, we must learn

827

to face them and seek solutions in whatever ways we can. Another way people react is to exclude such problems from their minds and escape into a world of fantasy. This we will explore later.

The same issues arise with the other less catastrophic problems on page 14, and in some cases solutions are forthcoming. This is especially the case with environmental pollution. The wide popular support of the environmental movement in the last two decades in this country has resulted in legislation on all aspects, the creation of the Environmental Protection Agency, the allocation of public funds for various kinds of abatement and research. The adage that "the only solution to technology is more technology" seems to apply here. On a profounder level, though this cannot be true, because technology cannot help supplant technological values with other values.

It is here that the scientist can help, not only as a citizen, but as a scientist. He can help by concentrating his talents and energies on those aspects of science which promote humane values, such as combatting pollution. This is instead of science in the service of profit, of the military, and more insidiously, science in the service of some individual scientist's private delight in unravelling nature for its own sake. Commoner has stressed this in his book "Science and Survival."[27] Ravetz calls it "critical" science.[28] Such expertise then strengthens the cause of humane values in the political process, and creates a moral climate in which such science takes on higher priority among all the interests of science.

When a proposal for some form of new environmental control is made, such as over emissions of hydrocarbons or lead into the air, polychlorinated biphenyls as pesticides, or nuclear waste storage, there is or has been violent public controversy, not only over values, but often over what the full facts are. It is too easy to promote one's pet value not so much by offering falsehood, as by selecting facts in such a way as to put one's values in a good light, to make the rational argument appear more persuasive. Even select panels of experts differ over values. On car emissions, the manufacturers will have one set of values, environmentalists another, government officials another, lawyers yet another. Nelkin's "Controversy: Politics of Technical Decisions"[29] describes several recent incidents. Each side in an issue parades its tame experts. The California Legislature even declared the issue of nuclear safety was "not resolvable by expertise," but required the participation of the general public. Perhaps in matters of public controversy one should replace the word values by interests.

Kantrowitz has suggested a way to resolve these difficulties by instituting what has come to be called the Science Court.[30] Advocates for different interests would present their cases as best they know how to a panel of judges, chosen for its expertise in the area at issue. The panel would then issue a decision, not necessarily of a guilty-not guilty nature, but in the best interests of all parties. The purpose of this is to separate the facts from the values. Ultimately there ought to be essential agreement over the facts, although of course not necessarily the values. Politicians oppose the idea and so do lobbyists: promoting facts rather than values has never been their way of operating. There are some real problems, such as finding the panel of impartial expert judges. On the other hand, presidents of many academic and professional societies endorse the idea.

Many authors have presented and discussed the issues of environmental and the other problems. "The Social Responsibility of the Scientist" edited by Martin Brown is a collection of essays by scientists addressing their relationship to government departments, especially Defense, which fund their research, the function of academic and professional societies in promoting humane values, technological warfare, radiation and other environmental pollution, population, food supply, and related matters.[3] It is significant that the book was published in 1971 at the height of the crisis over the Viet Nam War. The War did not cause these problems: rather it was a symptom of them. Now it is over and uneasily forgotten, we are becoming less vocal about the problems which are still with us. They are sure to surface again, though one hopes in ways less agonizing than a controversial and inhumane war.

Let us return to the matter of facing difficult problems or escaping to fantasyland. This is not simply a matter of conscious choice of what one will or will not think about. This is because it is a difficult task very often to come to grips with the true nature of a problem. Ellul wrote "The Technological Society" with the idea not of solving the technology problem so much as stating what the problem is. No problem can be solved unless it is first correctly described.

Trippett's "The Shape of Things as They Really Are" considers the unimportance of elections.[31] None of the great events in recent history were the result of popular vote, the world wars, the desegregation of American public schools, the New Deal. Politicans campaign for office on platforms of promises which are always broken. This is not because of their scoundrelism, but because their visions of what the problems of the world are like, and the public's visions too, are not real.

They are "folkloric." They correspond to what the world used to be like, or what we wish it was like. For instance, recent presidents have tried to bolster an ailing economy in the belief that it is dominated by the free market, that is, private enterprise. They have failed. This is because today's economy is not like that. Instead it is dominated by the "military-industrial complex," which is motivated by growth, not by supply and demand. Deeply aware of Ellul's description of technique as moving beyond human control, the author shows that politicians who are unaware of the real world cannot affect it, and thus governments are having less and less impact on it. Hence it does not matter very much any more whom the public elects.

What the politician and public see as problems in the folkloric world are often solutions in the real world. Trippett cites unemployment, urban slums, police surveillance as solutions, not problems. Unemployment is the solution to society's technological goal of efficiency.

Does this matter? There is no question that it does. There is an aphorism "Those who believe absurdity commit atrocity."

Cohn's book "Europe's Inner Demons" is a history of witchcraft in the Middle Ages and the Renaissance.[32] From the fifteenth to the seventeenth centuries tens of thousands of victims were tortured and burned in the name of religious zeal. His thesis is that witches were not revolutionaries, much less invalids from some psychological malady, but the creation of orthodoxy: the Roman Catholic Establishment itself. From the year 1000 on, this Establishment came under attack from within, from devout and intelligent monks, nuns, and lay people calling for reform. Rather than respond and reform, it pronounced criticism as heresy, the work of the devil. Later still its confidence was so undermined, it began to seek out seemingly harmless individuals showing some kind of anti-social behavior as scapegoats. Torture always secured confession to whatever evils the accusers dreamt up, and so the process was self-stoking. As Janeway points out in a review of this book, the issue here is really the delusionary thinking which sets in once things go wrong in a society from within.[33] When actions do not produce expected results, we lose confidence in the relation between cause and effect. "Can it happen again?" Janeway asks. "Does the current tide of interest in the occult portend the onset of that sleep of reason in which monsters are born? It is hard to discuss this question without appearing to take seriously what is intellectually ridiculous. But though the content of present-day occultism is certainly ridiculous, the extraordinary range and the rank, continuing growth of these phenomena suggest there's something going on we

should pay attention to." She then lists the enormous current coverage in books, films, television, and the press, and even academic interest in witchcraft, astrology, UFOs, ESP, telepathy, and one might add scientology, spiritualism and other cults, and the fascination with life on other planets.

How can we explain this interest? Cohn and Janeway suggest we are finding science and technology too hard to grasp these days, as our ancestors found Medieval Christianity. Not only is the overall nature of technology fearfully threatening and hard to grasp, but so are the intricacies of the details, the terminology, the symbolism, definitions, the mathematics, and the reasoning. Who among us, save the experts, can describe how the telephone works, or television, or detergents?

Can the horrors of the witch-craze ever return? In this century?

They have already done so. One man believed and wrote that mankind was characterized by a master race, and subject races which should be enslaved or eliminated. This was in response to a complex of nineteenth century influences, everything from Marx to Darwin's doctrine of survival of the fittest. A demented and eccentric fanatic? That man was Adolf Hitler, and a whole civilized nation elected him Fuehrer and followed him to the death through six years of peace and six of war. And he very nearly did fulfill his promise to eliminate the Jews.[34]

Trippett and Janeway show us in very different ways the great difficulty mankind has in grasping the true nature of things, and the results, sometimes absurd, sometimes horrible, of what we do when we do not grasp it. There could not be a stronger contrast between this state of affairs and the unfortunate but common idea that because science is truth, it can solve all our problems. We may indeed understand the physical world by the making of analogies and relationships between measurable facts. But there simply is no such thing as an adequate science of human affairs. And between these two, the physical world and human affairs, one should consider which is more important.

Lest we think that the influence of science and technology is wholly evil, it is well to remind ourselves of the benefits of the artifacts of science and technology, and in particular the value commitment most of us still have towards rational thought processes. How could it possibly be that the reactions of others of us to rationality could cause such evil? In order to explore this further, we must move even closer to the scientist at work than in the last chapter, into his mind, to study the process of science.

4

The Axioms and Process of Science

There is a difference between facts and opinions, and there is a difference between demonstration and persuasion. To demonstrate something is to present facts which must convince a rational mind of its validity. If I wish to convince you there are five people in the next room, I take you in and we can count them. Our feelings are not involved: facts are value-neutral. An opinion is a statement, though, which has value content. To convince someone to agree with an opinion, we preach, we attempt to persuade. Suppose I make the statement that Eisenhower was a great president. You may not agree. So we will attempt to convince each other, by listing all we can remember of a vast array of pertinent facts, trying to reassess actions and judgments back in the fifties. It is impossible to make an objective assessment of all of the huge quantity of material. So we can rely on hunch, on feelings. One of us may be converted: his opinion will have changed. But even so the "winning" viewpoint cannot strictly be demonstrated.

There are statements other than facts and opinions. Take the statement that a dromedary is a camel with one hump. This is a definition. "Dromedary" is a label. It tells us nothing new about the world. It is not demonstrable by logic--only by the conventions of dictionaries. Nor is it a matter of opinion.

What of the statement that you can only draw one line through a point parallel to a second line which does not go through the point? At first sight this may seem obvious, maybe an odd way to define parallel lines. However, Euclid, the ancient Greek mathematician, found he could not construct a watertight logical system of geometry unless he first assumed that this undemonstrable statement was true. Thus it does tell us something about the world. Such a statement is called an axiom or postulate. This one is in effect the fifth of five axioms in Euclid's book, The Elements.

There is an interesting similarity between axioms and dogma. Dogma is statements one may not question, for fear of authorities, whether men or holy writ. A true Christian believes that God has three aspects, the Father, the Son, and the Holy Ghost. Centuries ago to question this was heresy. Nowadays, one way question it, but only with the penalty of weakening the force and therefore the benefit of Christian teaching. Similarly one may question the axioms of Euclid, and inevitably, should the questions be good ones, one undermines the unity and clarity of geometry, and even the very grounds on which we regard it as truth.

Then there are statements such as "Species evolve by natural selection," which is true as far as we know at the present time, from the study and testing of a hundred years. However, history has gone to show that statements of this kind have a limited tenure. At some time in the future, new evidence may come to light which will modify or change the statement to preserve its truth. Such a statement is a scientific theory.

To return to Euclid, another scientific theory is that his Elements represent the real world. That is to say the geometry of lines, triangles, circles, conics, the famous Pythagorean theorem about the squares on the sides of right-angled triangles. And so they did for about two thousand years. Then in the eighteenth century Lobachevsky set out to see once more if all the five axioms were really necessary. He found that the fifth axiom could be omitted. But the result was a new kind of geometry, with different laws and properties. For instance, the angles of a triangle no longer added up to 180°. But the new scheme was perfectly self-consistent. This was very troubling to those who understood it, because it meant there were now two correct geometrical systems which were not compatible with each other. Later Riemann showed there was a further kind of non-Euclidean geometry which did away with the first axiom (that only one straight line could be drawn between two points). Skeptics could at any rate comfort themselves that Euclidean geometry described the real world, and that the other two systems were beautiful creations of the imagination.[35]

Then in 1881 came the Michelson-Morley experiment which attempted to measure the speed of the earth through the ether--a tenuous medium filling all space, which was invoked to explain the transmission of light. This was by measuring the speeds of light reaching the earth from distant sources in different directions. The experiment was successful. The result was zero. There was no difference. But this was a result which did not square with all known laws of physics at the time. So, as happens from time to time in science, there comes a discordant fact. This one was fundamentally discordant too, because it led through Einstein's Special and General Theories of Relativity (1905 and 1915) to the reinterpretation of the real world in terms of Riemann's geometry.

It is true the difference from the past is very slight--in terms of actual measured quantity. To all intents and purposes the result of the Michelson-Morley experiment has no direct impact on our lives. For all practical purposes we can go on regarding the world as Euclidean--except of course when it comes to such measurements of the speed of light.

However, the change impacts us very profoundly in two less direct ways. First, Einstein's Theory has enabled science to progress in a way that was impossible before. For instance,

without it there would probably have been no nuclear power, no atomic bomb.

Second, this is one more lesson that no theory lasts forever. The theory that Euclid's geometry describes the world is now obsolete. What was held to the truth about the world for two millenia, from civilization to civilization, is found to be no longer true.

This is a usual situation in science. Its history is littered with obsolete theories, none perhaps as hallowed as the Euclid one. The world was once thought to be made of four elements, earth, air, fire, and water, and not the current total of about 104. It was once thought that the earth was the center of the universe. It was once thought that substances burned by releasing a fiery material called phlogiston. And so on.

It has been customary over the last century to look upon the development of science as an onward and upward ascent, a part of the larger effect of Progress, the material and spiritual betterment of man.

We must guard, though, against the conclusion that earlier scientists were less able, competent, or brilliant, or in some way more primitive. If one studies them and their work in the context of their times, there is no evidence for this. Of course, in earlier times the interests of scientists and people generally may have been different, but this means then that there is no comparison between different ages.

Accepting then that no theory lasts forever, we come upon a startling discovery: there is no such thing as absolute truth. Our knowledge is forever limited. Mankind as a whole cannot know everything, and never will.

At this point it is natural to inquire how we can be certain of anything we know. There are two routes towards this. One is to copy Euclid and seek axioms for science as a whole, unprovable statements necessary that science can progress. The other way is to follow closely the process of science, how theories develop, the design of experiments, and the nature of hypothesis.

The axioms, the bases of science are as follows:[36]

The world exists.
We can know the world.
We can know the world through our senses.
Phenomena are causally related.
Phenomena occur in time and space.

It is perhaps superfluous, even irritating, to be faced with such statements of the obvious which cannot be usefully questioned. But it is important here to note that they are not facts but axioms. They are not demonstrably true. They are of value because they enable us to pursue just those aspects of the world which we can agree upon. They are needed so that we can grasp the world. We must also recognize and accept the value connotations. The axioms are true because we wish them true: they ought to be true.

Some of them are worth questioning, just the same. Are there ways we can know the world other than through the senses? Certainly, there is intuition, and there is religious revelation. Intuition is the recognition of new knowledge whose origin we are not conscious of. Most of us have intuitions at some time. Revelation is rare. Yet throughout recorded history there are instances, some very famous: St. Paul's vision of Christ on the road to Damascus; the vision of St. John reported in the Book of Revelation; the revelation of Muhammed the Prophet; the revelation of the Book of Mormon to Joseph Smith. Their recurrence suggests their legitimacy as a human function even to the most objective mind. In this context though we observe that however legitimate intuition and revelation may be, their contents are not scientific. A revelation may be preached, but never demonstrated.

Are there phenomena not caused? Again, not in a scientifically demonstrable sense. However mankind has believed in the relationship of phenomena at various times which we now regard as uncausal.

The I Ching is an ancient Chinese book of divination, or an oracle, from which one can draw answers to questions about life, questions about how to make decisions, questions about values. This is not the place to give a detailed introduction to this complicated and difficult book. However, the procedure for using it reduces to framing the question, tossing coins to discover where to look in the book, and then interpreting the advice given according to various qualities possessed by the heading under which the advice appears, and certain other headings which are cross-referenced.

Few people with a Western upbringing would pretend that the decision or answer reached is caused by the tossing of coins. Yet that is just the way several non-Western cultures attempt to make an inscrutible and changing world yield knowledge or wisdom. There may be a relationship between the heads or tails and the world around us. But it is not causal, not scientific. The psychologist Jung used the term "synchronistic" to label the relationship, thus focusing on simultaneity in time.[37]

Can we conceive of phenomena not occurring in time and space? Dreams, maybe? Of course a dream occurs on a certain night on a certain pillow, but the world of the dream does not. Which is more real? What about the events in a novel, play, or film? Did Hamlet really put off killing the King until it was too late? We must set aside the tenuous connection of Shakespeare's play to historical facts (there really was a Prince Hamlet) and recognize it, and all of these things as imaginative: exercises of the creative mind. And what is the imaginary world if not the opposite of the real one, a world freed according to the poet's choice from the constraints of natural laws, which (almost) never change? We may further distinguish dreams from artistic creation by their unconsciousness. They are not willed or planned or designed.

Lastly we must consider a further axiom which has been deliberately excluded from the list. It runs: Our knowledge is independent of the mechanism of human mentality and is true for all time. This must be so for science to be truly reliable. The purpose of the earlier discussion of Euclid though was to suggest that no knowledge is independent or permanent. The very history of science demonstrates this. If proves that our understanding of nature is never fixed, but continually evolves. If we insist on this, then science itself is unscientific! Thus the peril of questioning axioms. Evidently, in order to have complete faith in science, we must believe with Henry Ford that history is bunk. Rather than force such a confrontation between historical and scientific evidence, it would be better to exclude the axiom, and accept the shadowy inconclusiveness of science. Perhaps science is unscientific in the same way that geometry is now non-Euclidean.

The change is not sudden. It is deeply rooted in the past. Doubt about Euclid's fifth axiom goes back to Proclus in the sixth century, maybe to Euclid himself. Doubt about the absoluteness and permanence of science is to be found in mystical Neoplatonism of the third to the sixth centuries, and the Scholasticism of the middle ages; in the Catholic hierarchy that imprisoned Galileo in the seventeenth century, and in the Romantic Movement of the nineteenth.[38] There is one factor which is new. In older times, science was not dominant in the culture, and it was natural that its assertions were questioned, especially when they conflicted with religious authority. Now that science is dominant in our culture, it is disturbing and difficult to accept its transient nature.

Having recognized the axioms of science as value statements, we should add to them statements which express the value of science to man. These are:

28

In any question, it is good to stress those issues which may be illustrated or decided scientifically.
The more knowledge the better.

Now we have five statements which tell us how science can be, and two which tell us why it should be.

The first of the two, although it is a value statement, exalts facts over values. It is a credo for Kantrowitz's Science Court (page 21). Substitute "rational" for "scientifically," and it is the reason any chairman calls for order. It points the way not necessarily to individual enlightenment (although that is not excluded) but to human agreement. It would be nice to think of it as the path to peace. But that is not the nature of human society. Historically, neither science nor technology has brought about peace.

It is belief in the last axiom which has caused the explosion of knowledge. It is in serious doubt today. Some years ago C.P. Snow wrote "The Two Cultures,"[39] drawing attention to the different educational and cultural worlds of scientists and engineers on one hand, and of humanists, those trained in philosophy, history, literature, and religious studies, on the other. This was in a British setting, where the differences appear more polarized than in the U.S. He said more technical people should be involved in government, the better to address political questions with technical content. The article created controversy at the time, but had the merit of drawing wide attention to the communication problems between specialists and each other, as well as non-specialists. If we don't understand each other, we can hardly cooperate to solve problems, or for any other enterprise.

Pirsig has pointed out that the effect of the unbridled pursuit of science has been not the selection of one truth from a multitude, but the increase of the multitude.[40] No one man can now know all of science any more, not chemistry, not even say silicon chemistry. Even though the 476,000 papers in a year of Chemical Abstracts are knowable, provable, reproducible, and communicable, in short good science in every way, their sheer bulk puts a new limit on communication. Their communicability stops being an actuality, and becomes an ideal. The professionals do their best, meeting this situation by ever increasing specialization. To the rest of us, science retreats to the shadowy world of an inhumanly large unread and unreadable book. We know it can be read in part, but never fully grasped. Jorge Luis Borges has written a story "The Library of Babel" which starkly illustrates this problem.[41] Our imaginations then go to work creating possibilities, and our fears become aroused as to the way some professionals, the dictators and militarists, use the great book. Then come the witches once again.

Thus the results of depending on axioms are no longer reassuring. If this conclusion be at all convincing, then we must ask why we have admired and fostered science so long and to such an extent, and what have been the motivations, indeed the values, of the scientists.

Before addressing these questions, let us first return to the other route to certainty and follow the process of science, or what is meant by scientific method.

It was Aristotle, the ancient Greek philosopher (384-322 B.C.), who first conceived the idea that one could learn the truth by going out and observing nature, rather than by dogmatic statements about the supernatural, hence such books as Parts of Animals and Meteorology. Later came Archimedes (287-212 B.C.), who designed real experiments with floating bodies, to show the upthrust was equal to the weight of water displaced. His famous response to this discovery was "Eureka, I have found it!" However, despite later figures like Galen the physician and Ptolemy the astronomer (both of the second century A.D.), experiment never caught on as a method of discovery in the ancient world, and Greek science declined.

It was not until the seventeenth century that the modern tradition of science began. It was then that science came to be a quest in its own right, independent of established religion, and what had become by then the dead weight of Aristotelian teaching. For long it was independent of the universities too. It was then that the scientific societies began, and the regular publication of annals, containing recent new work. Very influential in this was Francis Bacon, the great English philosopher and administrator. Although he was not himself a scientist, he made clear guiding statements on how and why science should be done. He said the study of nature should be by "mechanical aids" and the "test of experience" rather than by "intense meditation and perpetual agitation of the mind," so as to "penetrate" to "certainty and demonstration."[42] It was also to be specifically for the "benefit and use of life."[43]

After Bacon, science became the perception of relationships in already existing facts, and the design of experiments to test the relationships. The perception is called scientific hypothesis and if it survives the further research, it becomes a theory. This process, from facts to hypothesis to more facts to theory has been hallowed as the epitome of the rational mind at work, the demonstration of the power of the intellect over nature. There is no question as to the power. The impact of science and technology is all around us. But there is a question about the rationality.

Hypothesis is mysterious. Scientists have seldom explained very well how they come by hypothesis. There is the famous story of how Isaac Newton discovered the gravitational attraction of the earth and the moon by observing an apple fall.[44] It then occurred to him that the attraction of the earth for the apple and all objects might reach out into space and hold the moon in its orbit. That was a new idea. Up to this instant in 1665, mankind had adhered with varying degrees of faith to an older idea, that the heavenly bodies moved in circles because it was their natural tendency to do so. That is, the tendency could not be usefully questioned. Newton thereupon calculated the forces the earth exerts upon the moon and upon the apple, and after adjusting for the distance found them to "answer pretty nearly."

The mathematician and philosopher Poincaré relates that he perceived the relationship between two hitherto unrelated branches of mathematics while on vacation, in the instant he stepped onto a bus.[45]

The physicist Szilard realized the military implications of the recently discovered fission of uranium one day while waiting for a red light to change.[46]

It must not be supposed that these men were subject to revelation of a religious sort. Even though each received intuition apparently in a matter of seconds, the experience cannot be separated from hours of intensely hard work each had been doing at the time on related matters.

Bronowski, in his "Science and Human Values" stresses this process as a recognition of hidden likenesses.[4] The moon is like the apple. The one kind of math is like the other kind. The release of energy in fission is like that of a very large bomb--in extent and speed. And the man who discovers these things is filled with excitement and wonder--and it must be added, concern: Szilard strenuously opposed the use of the Hiroshima bomb in 1945.[47] But the initial perception was breath-taking. Bronowski shows that the emotional reaction is not unlike that of a poet or a painter in creating his art. Furthermore, he shows that these activities are also discoveries of hidden likenesses, and there are demonstrations of this from the poetry of Shakespeare and the art of Leonardo and Blake. Further still, those of us who appreciate the scientific hypothesis or the poem or the painting, recreate those hidden likenesses and thus participate in the experience of its creator.

It must be clear by now that science is more than just the facts which nature provides, which are all that nature provides. The science is the relationships, the likenesses, between the facts. These relationships must always be created by people. Without them the world is still the endless eddy of incomprehensible

phenomena it was to the Greek philosopher Heraclitus. Without these relationships we cannot know the world, and we are violating one of our axioms.

And yet their discovery is not rational. For all the knowledge, wisdom, and hard work of an individual scientist or artist, we cannot specify where the new likeness comes from or how, and neither can he. He cannot plan for it, command it, or predict it, nor describe it in advance.

Perhaps its esthetic attributes, its elegance, its beauty and the overpowering emotional reaction, which all of us seek in some shape or form in our lives, arise from just this remoteness from human consciousness and control. There is something going on which is beyond our ken.

It is worth digressing here to explore the relation between scientific hypothesis and artistic creation with the use of language. Jaynes has recently proposed a startling new hypothesis for the nature of human consciousness, and how it may have developed in recent millenia.[48] Consciousness is an analog of reality in the mind made with words. That is, it is a map: the relationship of reality to our perception of reality is the relationship of the land to a map of the land. The words we use are only connected with the things they represent by social convention. There is nothing in common between the written word tree (except perhaps in hieroglyphic writing), or its pronunciation, with the object growing at the edge of a field. Rather than have a separate word for each object or idea, we often make the objects and ideas share words where the one suggests the other. We speak of the mouth of a river, thus indicating what it is like by association with part of our anatomy which is more familiar. And similarly the mouth of a bottle, or the muzzle of a gun; and while talking of guns, their thunder and the thunder of diesel engines; and more abstractly, the flowering of an artistic style, or of genius, or of youth. It is not hard to suggest familiar phases of this sort. The map of reality above is itself another example.

When used in a literary context, such a device is called metaphor, but Jaynes shows that it is a much more fundamental and pervasive part of human language than literary usage would suggest. He even traces the word "be" to its Sanskrit source which means "grow." Thus we even need a metaphor for so fundamental a matter as existence. Metaphors then are the structure of our consciousness. They help us make the unfamiliar familiar. They are necessary that we know the world.

And yet what are metaphors but the revelation of hidden likenesses, Bronowski's phrase for both scientific hypothesis and for artistic creation? Every algebraic equation, applied to a phenomenon in nature, expresses a likeness. The equals sign means this. Every painting, realistic or abstract, expresses a likeness. The success of the hypothesis, or the fame of the painting may be related, at any rate in the first instance, to the excellence of its author, his success in communicating the likeness and the associated emotion. To Tolstoy, art was the communication of emotion.[49]

So in this sense the pursuit of science and art are extensions of the pursuit of language, which is itself the expansion of consciousness. The satisfying or pleasurable feelings we experience point to an inborn urge or instinct towards these pursuits.

The unpredictable nature of hypothesis seems to be in conflict with the assertion in an earlier chapter that scientific research can be and is planned and budgeted in advance. So we have now to distinguish between the kind of research which yields new hypotheses, and the other kind which tests old hypotheses. Almost all research, pure and applied, comes in the second category. Kuhn, in his book "The Structure of Scientific Revolutions" puts both kinds of research into a historical perspective.[5] The testing of old hypotheses he calls "normal" science or "puzzle-solving." A new hypothesis, especially if it is a fundamental one like Newton's Gravitation, provides a fertile source of inspiration for all kinds of new experiments. First there are the crucial tests to see if it has any kind of general validity, after which the hypothesis traditionally becomes a theory. But the testing continues in ever more subtle and sophisticated ways. The theory then constitutes a paradigm or overall model for this normal science. Indeed, if the theory is a long-lasting and fruitful one, it is easy to see how it comes to be regarded as the true nature of the world, truth which can never change.

That is why change when it does come is revolutionary. To replace a tried and trusted theory takes not only new data, but new terminology, new definitions, a disruption of the old habits of thinking. Kuhn shows that when this happens the adherents of the old and the new can no longer convince each other easily, because of the breakdown of communication. Thus the way by which a scientist comes to follow the new way is more like religious conversion, than it is like demonstration. In other words, it is quite non-rational.

Another feature of scientific revolutions, related to this, is the difficulty which occurs sometimes in figuring out exactly who

was the author of a revolution. Revolutions seem to happen because the time is ripe, rather than because of the insight of one solitary genius.

A clear example of both these features is the overthrow of the phlogiston theory of combustion, at the end of the eighteenth century, through the discovery of oxygen.[50] We do not know who discovered oxygen. This is not because of any lack of historical data. It is because several eminent chemists clearly succeeded in making it without recognizing the full significance of their work.

One of these men was Joseph Priestley. He spent a life-time making fascinating and very important contributions to our knowledge of the chemistry of gases, including the first recognition of several of the oxides and acids of nitrogen, and the preparation of oxygen itself by heating mercuric oxide. He was acutely aware of the problems of explaining the burning of things by the giving out of the fiery phlogiston. (For one thing, metals increase in weight on burning, and the idea of phlogiston having negative weight was as difficult to accept then as now). However, when a group of chemists from France, led by Lavoisier, proposed their entirely new hypothesis of combustion, and entirely reformed the terminology of chemistry in the process, Priestley could not accept the hypothesis or the terminology. In true scientific manner, though, he questioned first the new data, in a long paper in 1796, fascinating for its lucidity, reasonableness, and attention to detail. We should not be led astray in estimating it by our later-day training in and acceptance of Lavoisier's chemistry. It is the novelty of Lavoisier at the time which is the point.

The terminology problem was in the word air. Priestley called the gases he made not gases but airs: fixed air, inflammable air, dephlogisticated air. So did other chemists of his time and earlier. The tacit assumption was that there was really only one air--that is, one kind of gas--an idea that goes back to Plato and beyond. Thus in making different oxides of nitrogen, he thought of himself as conferring different characteristics on air. It was not yet as clear as it is to us that this process was what we have come to call chemical.

Priestley was refuted the very next year.[51] But that does not diminish him, nor his earlier contributions to chemistry. All the great scientists ask questions, and dare to be wrong.

There has been academic controversy recently over the significance of scientific revolutions, and thus the nature of scientific knowledge itself. Kuhn's distinction between normal and revolutionary science has been criticized as too sweeping. The idea of normal science is attractive however, as it comes closer to

the reality of modern industrial research than earlier more academic approaches. Also, there is Popper's view that science, since it is not provable for all time, must be falsifiable. Lakatos distinguishes various kinds of falsifiability, and sees science as contending research programs which evolve in time, rather than as rival theories. Feyerabend says there are no rules in science, other than "anything goes."[52] If so, then there is no such thing as scientific method.

To conclude this chapter, let us return to the beginning and think further about facts. At this point they probably seem the clearest of the several statements defined. What can be more dependable than the boiling point of water, or the number of people in the next room? They can be measured or counted, and no sane person will disagree with the results. Further, theories may come and go, but that boiling point will never change. (Assume it is pure water at sea level.)

Unfortunately, understanding this fact depends on our shared understanding of the concept temperature. This is quite new. The distinction between heat and temperature is hardly two hundred years old. It may even turn out to be transient. The Greek theory that the world was made of four elements is obsolete because their concept of element is also obsolete. It has been discarded as no longer a useful way to describe nature. The same must ultimately be true of all our concepts, including temperature, and even number. It is reported that a certain primitive tribe exists today with no sense of number.[53]

These ideas may seem remote and theoretical. Perhaps we can end with the value statement that it is good to grasp the deficiencies of science as a way of knowing the world. This is because blind faith in the wonders of science can lead to the human problems described in the previous chapter. Or more subtly, such faith can promote the values of scientists to higher priority than human well being.

5

Values and Scientists

For all the difficulties in accepting the results of scientific research as truth, there are certain profound consequences of the scientist's insistence on the reproducibility of his and his colleagues' findings. The facts must be demonstrable, and the theories too--for as long as they are able.

From time to time a scientific paper appears in print where the work described does not meet this criterion. Its professional readers, fascinated by the implications of the paper will plan related research, fail to get anywhere, and then repeat the work in the paper. If it isn't reproducible the author will be told, and if he agrees, he will publish some sort of retraction. Usually an honest mistake has occurred. Very occasionally, there will have been willful fabrication of data, in which case the author will quickly lose his reputation, and maybe his job.

As Bronowski says, honesty is part of the process of science. It is not something imposed by law, nor by codes of ethics officially agreed upon by every profession.[54] Without honesty there is no science. From this Bronowski frames a powerful value statement, applicable far beyond the confines of science, pure or applied: we should act so that truth is provably true.

It is here that scientists come into conflict with governments, which have no such value. The Papal government in 1633 could not tolerate Galileo saying the earth moved around the sun, rather than the reverse. He was forced to recant, and placed under what we would call house arrest. This was because this idea was in conflict with certain religious dogmas at the time about the nature of the universe.[55]

The case of Einstein is more complicated, because in addition to being the greatest scientist of this century, he was an outspoken pacifist and advocate of world government.[56] It was not that he was very influential by reason of his political ideas per se. His unique prestige lent importance to anything he said. He was intolerant of any kind of authoritarianism, including that of the German Government in the First World War. It was with great misgiving that he went to live and work in Berlin in 1913. He was an early target of Nazism for all these reasons, and further because of his Jewish descent. So when Hitler came to power in 1933 while he was lecturing in the United States, Einstein found it wise not to return home. Germany lost scores of her greatest scientists, artists, and intellectuals at this time.

As we have seen, it was the irrationality of Nazi beliefs which made them vulnerable and therefore intolerant of any kind of dissent. In science there must be dissent. There must be questioning. Otherwise there can be no agreement over what is true. Bronowski sees the tolerance of dissent as necessary to a healthy society.[6]

In the eleventh program in his television series "The Ascent of Man," entitled "Knowledge or Certainty," Bronowski expands on this concept of tolerance.[57] He proposes a metaphor for the tolerance of society for dissent. It is the tolerance of scientists for the impreciseness of their measurements.

It has long been known that no quantity such as the length of a plank can be measured with absolute precision. For one thing, no instrument is capable of it. For another, using our so-called Arabic numerals, such a measurement would have to have an infinite number of decimal places, and our mathematics cannot handle such numbers. (This is true for most scientific measurements, which are of continuous variables. Some variables, such as the number of half-waves in a vibrating string are by nature whole numbers, and can be counted precisely.) The nearest we can get to a continuous variable is to give the mean of a set of measurements and their standard deviation. Then using statistical theory we can calculate the likelihood of the true value being a specified amount away from the mean. It is a very powerful tool in science, to be able to say, yes, we are uncertain what a measurement is, but to say also that we know <u>how</u> uncertain.

There are two other ways in which scientific measurement is incomplete. If some object, a human face in Bronowski's example, is studied with light of different wavelengths, each wavelength will reveal some aspects, but not all. Even the total information from all wavelengths will not reveal all there is to know. The character of a face cannot be measured at all.

The other sort of impreciseness was introduced into physics in the 1920s through the development of quantum theory. It has been discovered that matter at the subatomic level behaves very differently to matter on a gross or macroscopic scale, as for instance the size of man or his artifacts. There is no intrinsic reason why this should not be so, but it turns out that the precision of one subatomic measurement depends on the precision of other such measurements. The uncertainty of the position of say an electron is related to the uncertainty of its energy: the higher one is, the lower the other has to be. One cannot be certain about either in the same instance. This in outline is Heisenberg's Principle of Uncertainty, or as Bronowski would prefer, of Tolerance.[57] The force of the Principle is not that we don't know, but that we can never know.

The Principle is too new, as are quantum mechanics and relativity to which it is related, for these matters yet to have made much impact on the public. We are in a period roughly corresponding to the fifty years following the publication of Newton's Principia, which was a period of digestion. But as with Newton, there is no going back. Scientists are puzzled, perturbed, and fascinated by the uncertainties of subatomic physics.

We should return to Bronowski's metaphor: tolerance in politics is as tolerance in science. Is there an identity here? Or is he making another value statement: tolerance in politics ought to be like tolerance in science? If so, then we will have potentiality, never actuality. We can urge, teach, and preach, but not demonstrate, nor enforce.

Does this insight diminish the force of Bronowski's message? Would his preaching have struck home better if we had remained ignorant of this limitation to his argument, which he was careful not to point out? If science is in need of promotion for its positive value in the modern world, isn't such an analysis reprehensible? Yes it is, in a certain context. The context though is that the positive value of science outweighs and is separable from the liabilities of technology. As a matter of historical development, this is no longer true.

However, as long as we respect the scientific method, we bind ourselves to the demonstrability of truth as well as to tolerance of nature's uncertainties. That is why science has been a moral pursuit. Science is a mechanism by which we attempt to enforce the value truth upon ourselves. That is why Bronowski and Hoyle also celebrate science as the most characteristically human of human activities. Only humans among creatures can be rational. The facts that the quest is imperfect and never ended do not negate the value of science. They merely demonstrate the limited nature of man's ability to know.

The situation of technology under dictatorship is very different indeed. One of the greatest technical triumphs of all time was the V2 rocket. Here was a vehicle which could rise to sixty-five miles and fly at a mile a second, at at time before any jet aircraft became operational, and when world height and speed records were tiny fractions of these figures. Its development was completed under the auspices of the Hitler Government. There can be no clearer contrast between truth, the overriding value of science, and efficient means to ends, the overriding value of technology. War is a most powerful stimulant of technology.

So far, in this chapter and the last we have studied the ways in which values impact science; how science is dependent on value-related axioms; on hypothesis and esthetic value; how theories come and go; how science depends on truth and tolerance. We will now continue the inquiry into the enigmatic and troubled relation of values and science by looking in the opposite direction, at ways in which science has impacted values. Again the relation is ambivalent.

Historically, science can be shown to have had a beneficial impact over several generations in the seventeenth and eighteenth centuries, through the growth of humanitarianism, and the growth of the demand for objective justification for accepting moral codes.[58]

The moral codes propounded by the world's religions have always focused on individual rather than social values. "Thou shalt not kill" has applied to private consciences, not to armies. There is little in these codes about how the victor should behave to the vanquished, how one group should relate to another in political, cultural, or religious matters. With the rise of science in these two centuries, there is a stress for the first time on humanity as a uniform species. We see new values appearing which are still with us. For instance it is at this time that the anti-slavery movement begins. "We believe that all men are created equal," said Thomas Jefferson in the Declaration of Independence. Indeed he was ahead of his time, because a later clause in the draft of the Declaration attacking slavery in the United States had to be removed, for the draft to be passed by Southern delegates to the Continental Congress.[59]

Of course it is very difficult to show cause and effect here. Was the rise of humanitarianism caused by the rise of science, or was it the other way round? Such a question is almost impossible to answer, considering the great complexity of each movement. But they were simultaneous. Perhaps we can borrow Jung's term synchronistic (see page 27).

The other historical benefit of the rise of science was a change in our reasons for accepting moral codes. Traditionally the reason was authority. Those not accepting codes sanctioned by the religious establishment were threatened with excommunication, imprisonment, fines, torture, hell fire. Clearly it was unwise not to conform, no matter what the rights or wrongs were. Then with the coming of science came a call for objective justification for codes and laws. Today we label the earlier practices "medieval," or "cruel and unusual punishment," another famous phrase from the American Revolution. Kohlberg would say the old practices demonstrate a lower level of moral development as the norm.[14]

A very different influence of science on values is evident in the more recent rise of social science, where human values are often the data. Social science is often called a "soft" science. This is because the relationships between sets of such data tend to be true only statistically, rather than precisely, as the public still expects in physics, a "hard" science. For example, in pre-Relativity physics we can predict the strength of a beam, knowing its dimensions, shape, and what it is made of. The appropriate properties of the material are available in reference books, the necessary shape and dimension relationships in textbooks on the subject, and originally of course in research publications. We cannot predict, however, individual responses to sociological questionnaires on whether the sale of liquor should be banned, whether the price of petroleum should be raised to curtail imports, whether the current incumbent is a great president.

Science can therefore give insight and illustration into our values, but it is a mistake to imagine it can determine them. It provides answers to the question How?, never to Why? or Whether? It does not tell us which values to accept.

There is a grave danger in the soft sciences, that as we focus on the statistical connotations of values, we treat all values alike simply because they are values. It is as though we were to stop promoting the injunction "Thou shalt not kill," and instead raise our fists and cry "Down with murder!" The difference is that in the second case we implicitly recognize the existence of a coequal value system which accepts murder.[60] This "leveling" of values usually results in all values becoming subservient to the implicit assumptions that make such studies acceptable or important.

In economics, a grant of money from a foundation or a government department may be made on the ground that some proposal is "economic," meaning productive, profitable, or cost-effective, and completely ignore whether it pollutes the environment, causes unemployment, displaces people from their homes, or causes other violations of values which are not part of economics. This problem, discussed in E. F. Schumacher's "Small is Beautiful: Economics as though People Mattered,"[7] is like the problem of Ellul's technique, discussed earlier. Technique requires the promotion of efficiency over all other values.

To return to the physical sciences, the whole structure and thrust of teaching is directed towards cultivating an objective, analytical, orderly attitude of mind, to the exclusion of all non-rational thought processes. Esthetic appeal shows sometimes in an artless way, but scientists are not articulate about it. It has been said that the young go into physical science and mathematics to avoid human involvements. This is an overstatement, but there is some of this.

There is the danger in all branches of science that those of us who are or aspire to become scientists become so preoccupied with the truth it reveals and the beauties of hypotheses, that we unconsciously promote the values scientific truth and beauty above all other values. Then, whether it is nuclear physics or genetic engineering, we will pursue science as though people do not matter.

Thus we come to explore the motivations of scientists, to move as it were into their hearts.

Truth and beauty may be required, but there are many other values which motivate the scientist, and it would be well to compare them with the description of professionalism on page 11, bearing in mind the more intimate relationship with the scientist to which we have arrived.

As individuals the scientist and technologist are motivated by desires for promotion, honor, power, status, prestige, money, and independence. Even at the workbench such values affect the outcome of research. A researcher frequently reaches a point in his work where two or more alternative routes appear for further work. How does he choose? There are no data yet, and so he must guess, and time, money, and notoriety all play a part in the decision as well as truth.

At the technician level, all these values are present, perhaps in a less coherent way. Technicians may be less committed to a career, in which case the money becomes more important, as was said before, but there is still the satisfaction of doing the job well--the values of competence and excellence.

In none of these matters, other than the truth and the beauty, is the scientist-technologist-technician very different from other workmen. It would be nice to think that it is the truth and beauty which distinguish scientists from other professionals. Perhaps this is true, at any rate in the impressionable time of the teenage years.

However, scientists follow fashions. The atomic bombs in 1945 inaugurated a great growth in the power and influence of physics: in the funding for more research and more education in this area. What was the motivation? The perceived elegance of particle physics? Partly, no doubt, but there was also the irresistible psychic impact of the bomb itself. Further, there was less obvious but equally powerful attraction of the growth in influence: here was an area where we could earn well, rise fast, influence education, influence the government in ways quite new.

This impetus is now spent. Research is not progressing at the pace of thirty years ago, and as a profession particle physics is not longer attracting the young in the same way. It is the same story over again with computer technology, which is at the time of writing in the growth stage. However, the speed at which data can be processed, the smallness of electronic components, and the degree of interactive convenience for the programmer all have a limit, and so the growth here is limited too. The fashion for genetic engineering has barely begun, but by analogy this too will spend itself eventually.

Of course the fact that scientists follow fashions does not show them to be primarily motivated by extrinsic concerns. A current fashion may be popular precisely because it seems easier to seek truth in the particular direction dictated by the fashion.

Another motivation behind all this is job security. Gone are the days when we were content to earn our subsistence only. The technological imperative is upon us and science and technology as professions are and will remain intensely competitive. Jobs look securer in an expanding field.

There are more personal motivations. A scientist may pursue science because of the negative pressures from other factors in his life--family stress for instance. On the positive side, he may be under the continuing influence of some charismatic personality in his youth or later--a parent, teacher, or friend.

There is also the more enduring influence of great men. Particle physics did not begin in 1945, but developed from the discovery of the electron by J. J. Thomson in 1897. All physicists are close students of the great contributors, Millikan, Einstein, Planck, Rutherford, Schrödinger, Heisenberg and the rest, not only for their brilliant contributions to a profound scientific revolution, but for the character and quality of their lives.[61] It is interesting how pervasive these factors still are, long after the complete change of character that professional physics underwent after World War II. Note also that it is the highly academic great men who become the models rather than those who retreat to becoming administrators and bureaucrats, no matter how successful in those occupations. Einstein is preeminent here, not only for his stature as a scientist, but specifically because of his public contempt for authorities.

One cannot dissociate the motivation of scientists from the many decades in which science and other professions have been dominated by credentialism. The practicing technologist-scientist can neither get employment nor progress without his bachelor's or master's degree. The researcher has to have his doctorate. Most master's degrees and nearly all doctorates require some

original research. The enormous expansion in the output of graduates with these qualifications has become based upon the demands of industry, of the technique itself as much as upon enthusiasm of student and mentor for the subject matter of the research. The distinction that used to go with the academic title "doctor" has now waned. The subject matter itself gets ever more arcane, remote from ordinary experience. It gets ever more vulnerable to humorous jibes, such as Senator Proxmire's "Golden Fleece" awards. And behind the humor is a most serious concern for ethics as well as budget priorities.[62]

Clearly we now have science being done not primarily for love of science but for love of money. Perhaps that is too simplistic. Certainly science is done for love of professional advancement and in pursuit of power.

It is then clear to any ethically aware individual that scientists are no different from other fallible mortals, and that they do not deserve their special privileges--high influence, honor, and salaries. Of course this is a generalization. There still is splendid science being done, sometimes at great personal sacrifice. But it is not the honorable exceptions which dominate the public's consciousness of the place of science in the world. If this general impression be a true one, scientists can only blame themselves if the influence of their profession declines in the face of a popular protest.

The ethical problems of science have been analyzed in detail by Jerome R. Ravetz in his "Scientific Knowledge and its Social Problems."[2] Ravetz sees science as a social activity, where all the decisions, the choices of experiments, and the training of experts are determined by social mechanisms. He finds these mechanisms more important to the conduct of science then its philosophy--questions about axioms or hypotheses. The problems are shown to be inherent in the way science is done as much as the external pressures.

Science is controlled by methods which are informal, tacit, intuitive, and personal, rather than by written procedures, laws, public statements of policy. Ravetz says the relationship between a skilled scientist and students is not unlike that between master craftsman and apprentice in the Middle Ages, and so calls the work they do craftwork. As in the older crafts, some of the work is conceived non-verbally. This is a concept which has been recognized in technology also, as for instance in engineering design.[63]

The scientist is faced all the time with many judgements, where the craft skills go to work. He must choose who goes to graduate school, who does the research, which government agency or foundation will fund the research. He must judge what information to use from earlier published research, and how much reliance to place on it. He must decide who gets promoted. He must serve as referee, making impartial judgments on the quality of research papers submitted to journal editors for publication, by people working in the same fields as himself, even though he is in competition with them. Ultimately he must serve on the committees which decide who gets the grant money itself, and how much.

More generally, the profession as a whole has to judge which research results are of sufficient quality to be useful over a period of time. These then become what we call scientific knowledge, and filter down into textbooks and school curricula, even in some cases into common knowledge.

All these judgements, Ravetz says, demand a sense of etiquette, and a sense of ethics. The higher a scientist rises in the profession, the greater the need, and the more subtle the judgements.

Because of the huge rewards in money, power, and influence, all able scientists are sorely tempted to short-cut the etiquette and ethics. Thus modern science has a tendency to be shoddy, entrepreneurial, reckless, and dirty.

By shoddy science, Ravetz means research work which is unreliable, hard to reproduce, or yielding few results of low significance. The ultimate is work which is vacuous, or yields nothing at all, beyond a further publication to be listed in the author's resume. It is here that we see the social demand for science as a threat to its quality. As mentioned in Chapter 3, all science is dominated by the publish-or-perish syndrome. The scientist must at all costs publish, to keep the grant money flowing, to get tenure at a university, to preserve his job. His personal needs can thus easily dominate social needs for the science, the needs of tuition-paying students, and the less definable needs of the field itself at the particular state of development it has reached.

Social need for science is impossible to define or to agree upon. However one may well question the value of 476,000 chemical abstracts in one year. We have already said that no one can read them all. So that puts a value decision ultimately beyond reach.

By entrepreneurial science, Ravetz means science devised to promote the careers and fortunes of the scientists. Such people

will rise up the administrative ladder fast. Their research papers may well be mostly short notes, which avoid much of the editorial review process, rather than longer maturer papers.

By reckless and dirty are meant kinds of science which endanger life, such as nuclear fission, and possibly recombinant DNA; and science which pollutes the environment, such as the discovery and then manufacture of certain herbicides.

Ravetz sees hope in the rise of what he calls "critical" science, which is specifically motivated by humanitarian and environmentalist concerns. Examples would be the study of the generation and effects of acid rain, and the search for a cure for cancer.

At the present time however, critical science is very far from dominating all of science. So we are still beset by the problems listed on page 14. As long a critical science is with small influence, then the rest of science can only contribute to the worsening of these problems.

This does not mean that individual scientists have not recognized and addressed them. One of the most heartening aspects of the problems of science and technology over the years is the way scientists have taken the lead in tackling them. Their expertise has been useful, but the issues are human issues, not questions about the physical universe. And it is as human beings that they have acted.

There are the scientists who contributed to Brown's "Social Responsibility of the Scientist"[3] (page 21). Others led political actions to protect the environment here and abroad, even in the U.S.S.R.[64] Others called attention to and sought social action with regard to the problems of recombinant DNA.[65] One even became a minor party candidate for President of the United States, on a platform of rationality in environmental and energy matters (Barry Commoner, 1980). In the field of nuclear science alone, it is scientists who started and run the Bulletin of the Atomic Scientists, a monthly magazine published since 1945, who started and run the Union of Concerned Scientists; who won the Nobel Peace Prize leading a successful campaign to ban atmospheric testing of nuclear weapons (Linus Pauling, 1962). This campaign included a petition to the United Nations, signed by ten thousand scientists.[66] The activities of Einstein and Szilard were touched on earlier.

It is most important to note that all critical science must be by definition applied, in the sense used in Chapter 2. Pure

science, no matter how fascinating or beautiful, is motivated by its fascinations, by esthetic value, not moral value. Therefore we come to understand that pure science is inescapably inhuman, simply because it necessarily lacks the moral element. This is in spite of the renowned humanity of certain great scientists, especially Einstein.

There is another motivation or value, of a more inspiring sort, intrinsic in both science and in life generally, which might be called satisfaction, or competence, or excellence, or growth. Pirsig calls it Quality. Let us see if we can formulate a concept which makes these differing terms each an adequate label. We have already touched on this when considering hypothesis. Few of us rise, however, to making significant scientific hypotheses. This expression of our feelings is an essential human attribute, and occurs in all aspects of our daily lives, even in so practical and mundane an activity as maintaining a motorcycle.

Pirsig's unusual book "Zen and the Art of Motorcycle Maintenance" is an analysis of the concept presented with autobiographical reflections occurring during a motorcycle tour of the Western United States.[6] Along with the delightful travelog come flash-backs of a mysterious "gothic" nature into the author's past, revealing his unusual mind.

He begins by describing the tension over technology as caused by two different ways of apprehending reality. First is "romantic" awareness, a total unanalysed and undifferentiated awareness of the world, which excites our esthetic sensibilities, our sense of wonder. Second is "classical" awareness which is our grasp of the structure of things, our way of understanding things better by dividing them into component parts, or functions, with connections between them.

People who describe something as "cool", "far-out", "mellow", whether it be nature, physical experience, or an art form like music, are making romantic judgements. Such judgements are highly non-rational, instantaneous, undifferentiated. Note the place of slang: an attempt to communicate the uncommunicable by formulating labels agreed upon by a select few who have a passionate commitment. Such labels are of course a form of metaphor.[67]

On the other hand we become classically aware of, say, chemistry, by making lists; lists of elements, compounds, reactions, properties, laws, formulas, mathematical equations; and of all the relationships between them. This body of material then becomes what we know about chemistry. The process of classical

analysis has been prominent throughout this book. We have looked at the kinds of values, the stages of moral development, the divisions of science and technology (simple and complex, pure and applied, research and routine), the extent of the problems of science and technology, the axioms for geometry, and for science, and so on.

There is satisfaction, even beauty, in both ways of seeing the world, but Pirsig's thesis is that in pursuing the technological imperative we have downgraded romantic awareness. The romantic is now regarded as nice maybe, but not important. As a result we have the perceived ugliness of technology, loss of job satisfaction. Where we try consciously to put back a romantic veneer to technology (whether in the design of a fast food restaurant or of Disney World) the result is not real, but phony.

This effect has its counterpart in university education too, the "Church of Reason" Pirsig calls it, where one is taught to have a worshipful and uncritical attitude towards not only science, but all the scientific aspects of the arts and humanities too.

To Pirsig, the very division of the world into romantic and classical aspects is wrong, artificial, destructive. This is more than a value judgment because, as he shows, it is a condition of mankind which has developed historically. He blames the division on Aristotle and Plato, a conclusion however not easy to substantiate. It is hard to accept so fundamental an aspect of our being as caused by the writings of two thinkers, no matter how brilliant and influential. As we shall see, there may be a very different explanation of this historical change.

Before Plato all was Quality. And still to this very day, if we can only see the world correctly, is Quality. Quality is a version of reality in which romantic and classic are combined, yet not just a combination, but the origin of them, and the perception which motivates all we do and think. Quality is morality, beauty, and truth all combined, a totality of reality so all-embracing that Pirsig compares it to the God of Zen Buddhism, and hence the name of the book. But all description must remain an approximation, because the essence of Quality is non-rational, and therefore not even communicable in ordinary words. Indeed Pirsig insists it must not be defined, because to do so would put it wholly in the classical or objective domain. He provides a long development of this difficult idea, and shows how it contributes to our sense of well-being in the face of life's frustrations.

Quality then is a motivater of the scientist as well as the rest of us. It is the starting point for his commitment to the pursuit of truth, as well as to those aspects of his well-being which extend to science, his job satisfaction, his good feeling

about himself, his growth as a professional, and his moral growth as well.

Here then is one route to an attitude of mind where one does one's science with both joy, and a scrupulous regard for all aspects of its impact on the world and the self.

6

Science and Religion

We begin by contrasting science and religion. Science is an intellectual technique: as we have said, it deals with and exalts the knowable, the provable, the reproducible. It provides power over nature, the power of understanding. An essential component is the well-designed experiment to test the validity of newly perceived relationships between data, the data being the only component of science provided by nature. The data themselves are perceived by the five senses--extended of course by instruments.

Religion also has its intellectual side, but its center, kernel, or backbone is in non-intellectual belief. Belief in some external, superhuman, everlasting, perfect, and loving Other, we call God. Religion exalts the best in man, is a foundation of morality, is the best approach we have, some would say the only approach, to the elusive moral imperative, touched on in the first chapter. Religion has always stressed the seriousness and importance of divine revelation or inspiration, something impossible to demonstrate or reproduce in the scientific sense. Hence the importance of religious dogma--statements of "revealed" truth one may not question. Hence also a certain tension between religion and science which reserves the right to question anything and everything.

Religions as social organizations rise and fall like civilizations. No one any more worships the ancient Egyptian god Ra, nor Marduk of the Babylonians, nor Zeus and Athena of the Greeks, nor their Roman counterparts Jupiter and Minerva, nor Odin of the Vikings. However, the eclipse of these old religions was slow and usually painful.

The ancient religion of the Greeks was already questioned four centuries before Christ, in the writings of Euripides and Plato for instance. It thereafter continued to lose its hold, despite many powerful defenses and reaffirmations. The first chapter of Lucretius's great poem, "On the Nature of Things" from the first century B.C., dedicating the work to the Goddess Venus, is a most eloquent and moving example.[68] By the first century A.D., the whole Roman world was captivated by other more mystical religions. There was fascination with revived Egyptian gods, with Zoroaster of the Persians, with gods borrowed from the Celts, with astrology. Most of these cults were not long-lived: we may call them pseudoreligions. They did not add to the growth of civilization, only to its decay. Christianity itself was little different to start with. As it grew in

power and appeal to people's hearts and minds, it came up against a powerful entrenched establishment surrounding the Emperor, always conservative, sometimes cruel. We have all heard of Christians being thrown to the lions for public entertainment. Slowly Christianity dominated the pseudoreligions, and eventually the fragmented and creaking religion inherited from the Greeks itself. Christianity was officially tolerated for the first time by the Emperor Constantine in 313. It is said he became a convert himself on his death-bed. As little as seventy-seven years later, it became the only tolerated religion.[69]

What does this have to do with nowadays? History never exactly repeats itself, but the parallels between the first centuries A.D. and today are patently obvious. We also live at a time of high civilization, as the Romans, a time of great complexity in social and political institutions, of declining morality and declining observance of official religion. Our official religions are old, outmoded, and fragmented too. Perhaps the time is ripe for a major new religion. Certainly we have pseudoreligions: the interest of the West in Zen Buddhism, Scientology, Spiritualism, Parapsychology, the Jesus Freaks--one more in a long line of fundamentalist sects, and of course astrology, as was discussed before. It is true many have these things have roots in the past. The use is new: people seem to be searching for religious underpinning to their lives, which they perceive as otherwise absent. We may even call religious practice a biological urge, something instinctive like the satisfaction of hunger or like procreation.[70] To push the parallel rather far, we may compare the Commune movement, as an attempt by young people to remove themselves from industrial society, with the Monastic movement early in the Christian era, when people also retired from society, to be monks and nuns to better observe religion.

We have said the official religions no longer support. Certainly this statement will be denied by those who do perceive support. However, we should ask, rather in the same spirit as we did of scientists in the last chapter, what are the motivations of those who attend church or temple: for a sense of community, to seek power and prestige through church-related charitable activity, to satisfy a sensibility towards church music, to be entertained by a splendid preacher; or to render loving service to the Living God. And the response is similar too. All these things may play a part, but the last is necessary, as for science the loving service of truth is necessary.

The purpose of this account is not to urge adherence to any religion, but only to describe its decline. In a random sample of ordinary people probably less than ten per cent, maybe less than five, truly believe in God, and render the loving service, although of course more may appear to do so.

There will probably always be individual scientists. However, this comparison between their motivations and those of the church-going public suggests that science too, as an expression of the social will, may decline.

Having established that organized religion has declined, the next step is to describe the part that science has played in the decline. Earlier we referred to the tension between science and religion. It is more than tension. It has been all-out battle for several centuries. This is because each of the great scientific revolutions has in its own way undermined some aspect of religious thought and practice. Here are four examples of this.

In 1543 Copernicus published his great work "On the Revolutions of the Heavenly Bodies", which suggested for the first time, at any rate since the forgotten Aristarchus in the third century B.C., that the sun rather than the earth was the center of the universe. There was little evidence for this. Rather, the new hypothesis was much simpler than the old generally accepted one of Ptolemy (second century A.D.) and thus more elegant, one more example of the esthetic aspects of hypothesis. Thus it was a better basis for astronomical calculations. It was this latter aspect which assured its success.[71]

At first sight this change might be thought to have no religious implications whatever. However, to the medieval and Renaissance mind, God not only created the world but was essential to its harmonious operation; and mankind, the highest of the animals, was His principal concern. Thus the flat earth was bounded below by Hell, and above by the heavens. The heavens were concentric crystal spheres, each carrying its planet, and beyond them the sphere of the stars, and beyond that God Himself, who kept the spheres in motion. The further a sphere was from the earth, the greater was its degree of perfection. Only in God was total perfection attainable.

This picture of reality may seem strange and fanciful to us, but it is important to realize that it endured in various forms for over 1500 years. It is to be found, for instance, in Plato's Timaeus (fourth century B.C.) and in Dante's Divine Comedy (fourteenth century A.D.). In that long period it was every bit as real to men as the expanding universe of galaxies is to us. Indeed more so, because the aspects of perfection were a guide to understanding Scripture and to perfecting one's life morally. Thus the heavenly spheres were necessary to us. Perhaps the expanding universe is also necessary: but that has yet to be demonstrated. It may have esthetic appeal, but it has no morally improving qualities whatsoever.

After Copernicus, mankind is no longer at the center of creation, but only on the third planet out from the sun. The dogma of the heavenly spheres begins to lose its hold.

In 1687 was published Newton's Principia, the book which propounded the laws of motion and explained the planetary orbits (already known since Kepler to be elliptical) on the basis of the Inverse Square Law of universal gravitational attraction.[72] To this deeply religious man, this demonstrated anew the exquisite perfection of God's work. To his successors, though, it demonstrated that once God set the heavens running, He was no longer necessary. The universe became a machine, running like clockwork, needing only an external winder.[73]

Still, the astronomers had nothing to say about life, where the mystery of divine presence was still paramount. Then in 1859, the biologist Darwin published the Origin of Species, suggesting that plants and animals developed by the "natural selection" of traits most beneficial towards their survival, in another familiar phrase, the "survival of the fittest." This did for life what Newton had done for the universe--made it into a mechanism. Once God started it going, it continued of its own accord.[74]

By this time, science had had great impact on the authority of the Bible as inspired truth. For instance the Book of Genesis says that God made the heavens and earth in six days and rested on the seventh.[75] Further, Bishop Ussher calculated from the genealogies in the Bible that this occurred in 4004 B.C. While science could not be certain when or how the world was made, these facts began to look very erroneous indeed. The sciences of archeology and geology began telling us the earth was hundreds of millions of years old, providing evidence from dinosaur skeletons, rock formations and weathering, and the like.

It is possible to rehabilitate the Bible. One may insist with Newton that we simply know more now of how God operates. It is extremely doubtful if scientific accuracy was what the authors and compilers of Genesis had in mind. There is nothing in what we know of that remote period suggesting the importance of such accuracy. All the evidence shows that this and the other books were written as witness to the presence of God in human affairs. Exactness was not important: clarity, drama, and certainty were all-important. It thus is possible to believe in the integrity of the authors, and the existence of God as well, without insisting upon the six days.

It is also possible to interpret the Bible, by for instance translating key words is special ways. Perhaps the six days of the creation is meant to be read as six ages. There is always a resulting difficulty: we grant authority to interpreters instead of

to inspired writing. In the last analysis we may interpret ancient writing to mean what we please.

Except then for the two great mysteries, the origin of the universe and the origin of life, which still are mysteries, even though scientists are currently pursuing both with great zeal, God was banished from everywhere except the human mind.[76]

The fourth great revolution is the rise of psychology, the attempt to probe the workings of the mind from a scientific standpoint, beginning with the writings of Freud from 1893 onwards. Interestingly enough there is as yet no unified scientific description of the mind. Instead there are several incompatible hypotheses.[77] So the process of banishing God from the mind is not yet complete.

Out of the tradition of psychology has come a recent book which not only proposes a hypothesis for the relationship of religion to the mind, but reveals a startingly new relationship between religion and science. It is Jaynes's "The Origin of Consciousness in the Breakdown of the Bicameral Mind."[9]

As was described in Chapter 4, the book begins with a discussion of what consciousness is and is not, concluding that it is a map of reality within the mind made with words. The conscious mind has certain recognizable attributes. It can solve problems, make decisions, imagine a set of alternative futures, picture time in a linear, spatial way. (How else can we think of time, except as a long line extending one way into the past, the other way into the future?) Conscious man is also able to deceive.

If consciousness is made of words, clearly it must have developed after language. It is perhaps pointless to ask when this was, so far back into the mysterious past we assume it to be. But Jaynes rephrases the question. Let us look at the earliest writing, he says, and see if there are signs of unconsciousness there. He focuses on the Iliad, the famous ancient Greek poem about the Trojan War, written in about the eighth century B.C. The War actually happened maybe 500 years earlier. The astonishing thing is that apart from certain exceptions, probably late interpolations in the poem, there is no consciousness whatsoever.

How then can men conduct a war, or even parry the strokes and thrusts of the enemy, if they cannot solve problems and make decisions? The answer is right in the poem. These functions are performed by gods: Zeus, Athena, Poseidon, and the rest. Are

they real, or imaginative creations of Homer, the poet? Jaynes prefers to think of them as real, real in the sense that the men in the war actually saw them and actually heard them under conditions of stress created constantly in the battle situation: saw and heard them in hallucination, with such realism, that they could not be distinguished from what we would call the objective world.

There are two kinds of evidence for this. Having once posed this hypothesis, it is possible to explain much of what we know of the sociology, writing, statuary, and behavior of all ancient theocratic societies on the basis that they were dominated by this strange and alien mentality--Egyptian, Mesopotamian, Maya and Inca.

There are also vestiges in the modern world. Brain specialists believe that the speech function in humans emanates from what is known as Wernicke's Area of the brain on the left hand side, for most of us, but have been puzzled over what goes on in the corresponding area on the right. In left-handed people, and in right-handed too in certain cases of brain injury, the right-hand side can take over the speech function.

Electrical stimulation of the right side in normal people has been found to cause visions to appear and voices to be heard--usually of a peremptory, authoritarian character. This experience may be religions in character. It may be exquisitely beautiful or unbearably terrifying. Its nature and content are quite beyond the control of the subject.

There is also a quite common disease (so called, by an overwhelmingly conscious society), where the hallucinations appear without stimulation. This is schizophrenia, a term invented in the nineteenth century from the Greek for divided mind.

A hallucinating person is not conscious of the world around him, and nor are the voices. He loses his sense of self, and just those powers which were used to define consciousness, the sense of time, the ability to plan, to deceive. There is some evidence for these phenomena in hypnosis, glossalalia (speaking in tongues), and even in some aspects of our response to music and poetry.

Jaynes supposes that millenia ago, when the bicameral mind as he calls it was universal, man generated a response to any decision-related stress in the right hemisphere of the brain--unconsciously--from the stored-up experience of his lifetime, and this was then fed to the left side in the same electrical coding as the information from the five senses and of course speech.

And then the bicameral mind broke down. Jaynes provides some conjectures of why it became an inadequate determinant of behavior, an inadequate way for the ordering of society. These are natural disasters, population explosion, increasing contact between peoples of differing language and culture, and therefore differing hierarchies of bicameral gods, writing itself. But break down it did. The result was traumatic. One can read in the cuneiform of the agony of men deprived involuntarily of this mainstay of their existence. One can read it in the Psalms too. What had men done to so anger the gods that they deserted them? The result was the familiar religious concepts of sin, prayer, and redemption, which begin very roughly about 1000 B.C. Another result was the beginning of omen literature, augury, astrology, and thus astronomy, all efforts to divine the will of the now silent voices.

Yet another result is that we have a scientific hypothesis for the origin and continuation of religious practice. So in the sense we used earlier, God is now banished from our minds, or now rather, imprisoned in the right sides of our brains. But that is not all. Religion is not the only way in which we have responded to the loss of authorization for action once provided by the bicameral gods, nor the loss of certainty in this world, in which as Heraclitus said, all things are in flux. Philosophy is an effort to the same ends, and so too of course is science itself, which began in astronomy in the service of augury. Why, asks Jaynes, should we require that the universe make itself intelligible to us?

So we have now arrived at the very soul of the scientist's being, where we see science itself as a form of religion. To be more precise, we see both as different forms of the same quest. Science has been called a religion before, but as hyperbole, or comparison exaggerated for effect, a kind of metaphor. Now we see that metaphor made into an identity.

We also have an explanation, or at any rate a precedent, for the centuries of rivalry between science and religion. The bicameral gods were jealous gods: "Thou shalt have no other gods before me" say the Ten Commandments.[78] And the religious wars of all the ages bear witness to the incompatibility of religions.

One of the most astonishing features of the hypothesis of the bicameral mind is the rapidity with which mentality is required to change. One hundred generations is an instant in comparison to the millions of years one associates with the biological evolution of Darwin. There is also no reason why the mind of man need be regarded as set in its present configuration.

It is only proper to state in conclusion that the bicameral hypothesis is a hypothesis and not a theory. It is very new. It

must deal with much adverse evidence. For example, we said earlier that history is tending to repeat itself in the decline of religion. If so, we have a discrepancy with any hypothesis which proposes irreversible changes in mentality. Interpretation of this and other issues is difficult though, and thus confirmation or refutation will be slow. However, the hypothesis is truly scientific. It will stimulate much new research. It is susceptible to disproof by facts: an example of conscious writing from 3000 B.C. or earlier would be very difficult to explain for instance. It also has its esthetic attractions. It simplifies, orders, and clarifies a huge amount of very various data. It unifies psychology, brain surgery, history, linguistics, and archeology, as well as religion, philosophy, and science.

Attractive though we may find it, though, it would be foolish to think of this hypothesis in any way as a solution to the problem of science, technology, and society. As with Ellul, we see that we may indeed have defined a problem. Not solved it.

7

Rationale for Right Action

What may we conclude from all this? It is perhaps unsatisfying to end with something so unfashionable and seemingly ineffectual as a prayer. But there are only two fundamental determinants of human behavior, brute force of circumstances (such as poverty, pain, authority) and the inner discipline of values. If we wish to avoid the former, we must understand and accept the latter. The nature of man is that he may choose: the choice in general cannot be enforced. So therefore, if I cannot demand a right choice from you, then I must instead entreat you.

There are three main topics for entreaty, the knowledge explosion, competition, and seeing science whole. The presentation is towards actual or potential scientists and technologists, but only in the first instance. In the sense that all of us should know what we ought to expect of them, it concerns us all.

Firstly then, suppose you are doing research on reaction mechanisms in the nucleophilic attack on organic heterocycles, or maybe on the algebra of hypergeometric distributions. What are your motives? (Notice how even the terminology of my examples is strange--unless of course one of them happens to be in your area.) If you publish, remember you are adding more unread pages to the great unread book of knowledge. If it is simply a matter of a prestigious career for you, or even just a job, the situation is simple. You may be furthering yourself at the expense of your fellow man, which is hardly moral. By "expense" I do not mean doing him out of his job--competition is an inescapable aspect of all life--I mean adding to that book, with the consequent strain on our grasp of reality.

Suppose though your research helps cure cancer, or that you love your work so much you cannot bear to leave it, even under the most stringent economic restraints, as we may see, for instance, in the lives of the chemist Curie,[79] or the mathematician Abel.[80] Then I suggest you had better do it. But still the work will not be properly done, that is, scientifically done, unless you consider all aspects of its interaction with society.

Secondly, competition. Technology may promote this above other human activities, but it would be a mistake to hold it responsible for competition. Competition is a feature not only of human life but all life. Walk into the forest in the Adirondacks, and enjoy the quiet and peace there, away from the noisy, active, polluted, strife-ridden world outside. There too, though, is battle to the death. Observe the dying trees with their few leaves, starved of sunlight by more fortunately placed neighbors.

Respect for individual worth is a human value not to be read on the whole in the rest of nature. As against this we might note that organized warfare against one's own species is also not on the whole to be read in the rest of nature.

The one value represents civilized life. Science and technology are promoting competition, with war as its ultimate form. This is now not merely uncivilized, but utter annihilation--the end of all life.

The only recourse is the discipline of moderation and patience and courtesy: to be ever alert and watchful over our own technological, competitive, and efficiency-promoting activities, so that we do not infringe upon others. Constantly and consciously aware.

Pirsig is saying the same when he bids us as we climb a mountain to concentrate on the here and now, on the leaves, and the views. Forget about the top. There's nothing new there even when you have arrived.

In the same way, compete in life as you have to, but concentrate on the here and now, the associates and the job in hand. The company presidency is not all that worth having, unless maybe reconceived as a position where primarily one serves one's employees and customers. Pursuing it always was an exercise in self-glorification, an ego-trip. But now it promotes technological mastery. Affirming the humane rather than the technological must become an intrinsic value.

The other technology-promoting motive is simply greed. How much salary is enough? How much in fees? $40,000 a year? $50,000? If so, what motivates those who strive for $80,000 rather than $60,000? How many $100,000 cruisers are enough? And how many chalets, extra cars, money squandered in casinos, ten-day trips to ten countries, snowmobiles, stereos, home computers, and all the other toys? One of the most depressing things about surplus wealth is the unimaginative way most of it is used. How then can we use financial resources to promote humane values?

Lastly, can we learn to see science whole?

I would not have anyone refrain from the delights of tinkering with machines or finding out new things in science without cause. These things are uniquely human, as Bronowski and Pirsig urge, and a rewarding expression of our innermost impulses, the origin of which we can now understand from Jaynes. But if you do these things while closing your mind to some aspects of their total impact on or involvement with this world, then you do two things. You violate someone else's values, and you begin to lose touch with reality.

Suppose you have spent some years being trained or advancing professionally in nuclear technology. It is then to be expected that you may resent the interference of individuals and organizations opposing nuclear power (or war). They interfere with your efforts with Congress to get funding, with your relationships with the public, and sometimes physically with the construction of reactors. They destroy your credibility, and ultimately your job, not to mention the splendid technology you have given so much of yourself to achieve.

If that is an essentially complete description of your relationship with your detractors, then clearly you violate their values. This probably won't concern you in so far as their values can be argued to be wrong-headed and contemptible.

But you also lose touch with reality. This is because you violate the sixth axiom of science, that in an issue it is good to stress the aspects that may be decided scientifically. Many, many writers have argued forcefully, for example, Schumacher,[7] that the stockpiling of lethal radioactive waste, which cannot be neutralized, and which always eventually leaks out, to be worried about for the next thousand generations, is a crime against humanity of monstrous and unprecedented proportions.

It is not my purpose to dissuade you from nuclear technology. Nor is it to persuade you that Schumacher's arguments are compelling. That you must decide for yourself.

But if you have not entertained or considered them with the utmost seriousness, you are not a humane nuclear engineer. This is because you have decided the issue nonrationally, excluding what several people, all impressive in their different ways, urge is an aspect of reality.

You are then suffering from the same kind of delusionary thinking as the men who persecuted witches and caused the Holocaust. And millions, maybe billions may suffer a great deal more than you as a result.

It may be unjust to let one of the "doomsday" problems in chapter 3 stand for all science and technology. However, arguments of a generally similar nature can be made for all of these problems. This example has the advantage of demonstrating the issues involved with some clarity.

We must grope then to see the impact of science and technology on society whole. We must attempt to encompass in our minds as many of the complexities and ramifications of this impact as we can; to be realistic and rational about the arguments which have made the life and career of the scientist-technologist uncomfortable; and to respond with humility and seriousness to them. The attempt in published writing has already begun. One example is Holton and Morrison's "Limits of Scientific Inquiry.[10]

This is the plea which the aware scientist-technologist must not only hear, but make himself. If he does not make it, others will make the same plea, but on much less rational or comprehensive grounds. This already happened with the Hippie movement in the sixties. Few would pretend that this movement was based upon a rational evaluation of the impact of science and technology, except as it applied to the Viet-Nam War perhaps.

There was much good in this movement. But the ascendancy of non-rational attitudes means revolution rather than evolution. Perhaps this is necessary. But revolution against science means revolution against its positive attributes, such as the commitment to truth and communicability which it has fostered for centuries. A future without these values held paramount would be very different from the present. Dark, shadowy, unpredictable, and scary. For all the threats and exigencies of the present, we may well regard the evolutionary attitude with less fear than the revolutionary one.

Perhaps this is why Jaynes, Pirsig, and Bronowski in their different ways emphasize the past: Jaynes to reveal the true nature of the present, the others to attempt to retrieve lost but needed determinants of humane behavior.

Discussion Topics

In the college course on which this book is based, an hour a week was devoted to serious discussion of the questions raised in various source materials, some of which have gone into the making of the book. Some items are formalized group exercises, most are general questions.

The object of this list is not that the questions be answered, because most of them have no answer, or if they do, they are so value-based that there will be disagreement over individual preferences. Where this occurs, then the differences should be explored to the utmost extent. The object here is to demonstrate the kinds of questions that can arise, so as to encourage you to think of your own questions. Good questions are those that go to the heart of the matter.

It takes many minds to explore the relation between science and values, at least two, and ideally five or six. (If there are more, some participants have little opportunity to speak.) The discussion is most successful if you:

(a) listen attentively,
(b) consider all contributions seriously,
(c) take care not to dominate or monopolize the talking,
(d) frame your own contributions so as to try to increase everyone's understanding of what is discussed.

It is helpful if all participants make a written summary in advance containing the essence of the passage read, record some brief comments, make notes of good points made at the discussion, and write a conclusion to the whole exercise.

Lest we become too embroiled in the mechanics of this process, let us reflect on the deeper and more important purposes behind it, and listen to the words of Scott Buchanan, extracted from a speech given to St. John's College alumni in the fifties after his retirement:[81]

> Have you in the course of your life, before, after, or while you were at St. John's, become your own teacher? Have you yet recognized that you are and always have been your own teacher? Liberal education has as its end the free mind, and the free mind must be its own teacher. Intellectual freedom begins when one says with Socrates that he knows nothing, and then goes on to add: I know what it is that I don't know. My question then is: Do you know what you don't know and therefore what you

should know? If your answer is affirmative and humble, then you are your own teacher, you are making your own assignment, and you will be your own best critic.

Chapter 1

1. Make a square on paper and divide it into sixteen little squares, four by four.[62] Head the four columns "strong opinion", "mild opinion", "little opinion", and "no opinion". For each of the following statements, enter the key word in one of the sixteen squares, only one key word to a square. Key words may be removed to other squares as you proceed.

	Statement	Key word
(1)	A neighbor drives without seatbelts because he hasn't time or money to get the old ones repaired.	Seatbelts
(2)	Some chemical companies bury poisons in landfills, hoping none will leak out.	Landfills
(3)	A pilot drops napalm on an enemy village.	Pilot
(4)	Someone hides razor blades in apples that are then given to children.	Razor blades
(5)	A driver drives through a red light.	Red light
(6)	A smoker buys a particular brand because he identifies with the cowboy he saw in an ad.	Smoker (or cowboy)
(7)	The current president is the best one this century.	President
(8)	Someone owns shares in a chemical company making napalm.	Shares
(9)	Your grandmother contributes her eyes to an eyebank.	Eyebank
(10)	Amtrak will fold.	Amtrak
(11)	Many people live and work to the sound of several hours of music a day.	Music

62

Statement	Key word
(12) Banks close at 3 P.M.	Banks
(13) Israel should use nuclear weapons.	Israel
(14) Father is an alcoholic.	Alcohol
(15) Utilities pollute lakes and rivers with hot water.	Thermal pollution
(16) The President of Egypt flew to Jerusalem to recognize the State of Israel.	Sadat

Note that you are not asked to approve or disapprove, but to decide strength of feeling.
Compare results with others.
Select one statement over which there is much strong feeling, and compare the reasons why.

2. What underlying values are held by people who favor, or who do not favor the following?
   (1) A mountain view on a fine day
   (2) Caviar and fine wine
   (3) Electric toothbrushes
   (4) The United Nations
   (5) Experimentation upon animals
   (6) Welfare
   (7) Statements chosen from topic 1
   (8) Statements of your own devising
3. Compare and contrast morals, ethics, and values.
4. Give an example of a war that was fought over a moral issue. Does morality always win?
5. Construct a private list of your own most cherished values.
6. Where are you in Kohlberg's stages? How do you know?

Chapter 2

1. Give further examples of simple and complex science and technology. Is the difference a real one?
2. Should scientific research be publicly or privately financed?
3. Is it necessary that scientific research and undergraduate science education be conducted in the same institutions? Are these different activities in the university compatible?
4. Should education be for life or for employment?
5. If you move beyond your present or planned career, what will be your next career?

6. Discuss and add to the descriptions given of researchers, professionals, pure and applied scientists, technologists, technicians, administrators. What about technocrats?
7. Is professionalism compatible with unionism?
8. How do the following individuals place in the categories in question 6?

Racing driver	Computer-artist
General Practitioner	Stockroom manager
Director of NSF	High-school chemistry teacher
Einstein	Schweitzer

Laboratory director of the analytical services division of a high-technology industry
Woman Ph.D. in biology, full-time mother, and part-time college lecturer
Chemical engineer who "scales up" the preparation of a chemical from the 1 lb. level to the 1 ton level, designing the apparatus and analyzing the costs
Salesman of government reports providing latest guidelines for industry on environmental and safety matters
Other examples of real people

9. Are you proud of technology?

Chapter 3

1. Nader and others have called for new laws encouraging and protecting whistle-blowers. Is this desirable, or possible?
2. Give further examples of techniques and how they promote efficiency and restrict freedom.
3. Does it matter if means are thought of as more important than ends?
4. What are the advantages and disadvantages of computers? Rank them in order of importance. Is it possible to decide if computers are on the whole a blessing or a curse?
5. It will soon be technically possible to have on record everyone's history--of education, finances, tax payments, infractions of laws, trips abroad, public statements. In what ways is this desirable and undesirable?
6. Why do styles in art or music change? Do they get better?
7. Is technology ugly?
8. Is it harder to get work than it was a century ago? Why or why not?
9. Is critical science better than other kinds?
10. Is astrology dangerous?
11. Are the thirteen problems on page 14 really problems?

Chapter 4

1. What kinds of statements are these?

   The sky is blue.
   Nixon resigned in 1974.
   Safer cars cost more.
   The world will soon run out of fossil fuels.
   Beef is better than lamb.
   Einstein was a great scientist.
   Kodak is better than Polaroid.
   Most of the chemical elements are gases.
   A point is that which has position but no size.
   Atoms combine by sharing their electrons.
   The powers of government are to be divided between executive, legislative, and judicial branches.
   Small is beautiful.

2. Can you think of statements which can't be included in the categories on pages 24-5? What about the statement on page 22, line 19?
3. How can we know the world?
4. Is the I Ching useful?
5. Is science useful?
6. Is it possible to have too much science?
7. Give further examples of obsolete and current scientific theories, of hypothesis, intuition, and revelation.
8. Give further examples of common words or expressions which are metaphors.
9. Is science beautiful? If so, what makes it so?
10. What is scientific method? Has it ever changed, or is it our understanding of it which has changed?
11. Copernicus suggested in 1543 that the sun was the center of the world. What has since happened, if anything, to modify the truth of this?

Chapter 5

1. Why does science come into conflict with totalitarianism?
2. Why is it different with technology?
3. Discuss any difference here as revealing differences in the nature of science and technology, and in the values of their practitioners.
4. Does the imprecision of scientific measurements make them less valuable?
5. Is science good for us? Is the conclusion any different from that of, say, a century or two centuries ago?

6. Study any available example of a sociological questionnaire. What hidden values does it promote? What overwhelmingly important values are "leveled"? What others does it discount?
7. What values motivate scientists, technologists, and other professionals.
8. What are some other fashions in science and technology?
9. Who was the greatest scientist of the nineteenth century? Why? The eighteenth century?
10. What is the prime motivating value of scientists?
11. Ravetz says scientific research cannot be mass produced like soap.[83] Is this so?
12. What judgements must a scientist make in the laboratory, and in the profession generally? Is there any difference between the two spheres?
13. Is it enough for the humane conduct of science that a percentage of scientists become politically active to this end?
14. Is pure science inhuman? If so, was it always so? Is this the same thing as saying it is amoral?
15. Describe further instances of romantic and of classical awareness.
16. Is Quality a useful idea? Or necessary?
17. Galileo was warned by the Pope many years before he suffered house arrest. In retrospect, it is clear that he was very influential in the growth of science, although this is impossible to quantify. Let us suppose instead he was tortured and burned at the stake early in his life, and as a result, nuclear weapons were not invented until a hundred years after 1945. Would this have been good? Can such inventions be prevented? If so, how? If not, what should we do?

Chapter 6

1. What is the meaning of the word exalt used in the first sentence? Is its use correct here? Compare with the statement about religion lower down.
2. Is the comparison between Western civilization and Roman a true one? What further illustrations and exceptions can be made?
3. Is religion really declining? Or science?
4. Has science disproved the existence of God?
5. If so, does it matter?
6. If not, will it ever do so?
7. Does the environmental movement of the sixties have any religious significance?
8. Suppose the Jaynes hypothesis becomes a proved theory: do we need such a theory? What is its value to us?

9. Could our artistic sensitivities be receding, as our bicameral voices once did?[84]
10. Suppose science and technology do succeed in destroying all trace of religion, and the religious basis of morality, would this result in a world of unrestricted crime, corruption, and other immoral behavior? Is the religious basis necessary? Was it so in medieval times?
11. What exactly is the problem referred to at the end that Jaynes may have helped us define?

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Index

Abortion, 14
Absolute value, 2, 18
Academic societies, 8
Administration, 11
Alcoholism, 4
American Association of University Professors, 8
American Chemical Society, 8
Amtrak, 1
Applied science, 10
Archimedes, 30
Aristotle, 30, 47
Art, 31, 32, 33, 46
Astrology, 14, 50
Atomic bomb, 14, 19, 31, 41, 59, 66
Axioms, 24
Axioms for science, 26, 32, 39, 43, 59

Bacon, F., 30
Bible, 52
Bicameral mind, 54
Blake, W., 31
Borges, J.L., 29
Bronowski, J., 31, 33, 36, 60
Brooklyn Bridge, 12
Brown, M., 21, 45
Buchanan, S., 61
"But is this Progress?", 13

Cash value, 3
Causation, 27
Chemical Abstracts, 6, 29, 44
Chemistry, 34, 46, 65
Christianity, 22, 49
"Classical" awareness, 46
Cohn, N., 22
Commoner, B., 20, 45
Competitiveness, 18, 57, 58
"Complex" science, 6, 63
Computers, 42, 64
Concepts, 35
Conscientious objectors, 5
Consciousness, 32, 53
Controversy, 20
Conversion, 24, 33
Copernicus, 51, 65
Craftwork, 43
Crime, 16
Critical science, 45, 64

Damocles, 18
Dante, 51
Darwin, C., 25, 52, 55
Declaration of Independence, 39
Definitions, 24, 33
Demonstration, 24, 30, 31, 33, 36, 49, 51
Dictators, 19, 29
Dogma, 24, 36, 49
"Doomsday" problems, 14, 19, 60
Dreams, 28

Edison, T., 6
Education, 9
Efficiency, 17, 58
Einstein, A., 25, 36, 42, 45
Elegance, 32, 51
Elements, 26, 35, 65
"Elements" of Euclid, 24
Ellul, J., 10, 17, 21, 56
"Enemy of the People", 15
Environment, 20, 45
Esthetic value, 3, 4, 16, 32, 40, 46
Ethics, 3, 43, 44, 63
Euclid, 24, 25, 28
Euthanasia, 14
Expertise, 20
Explosion of knowledge, 14, 29, 57
Extrinsic value, 2

Facts, 24, 30, 31, 35
Falsifiability, 35
Fashion, 41
Feyerabend, P., 35
Florman, S.C., 12
Ford, H., 28

Freedom, 14
Freud, S., 53
Fritz-Haber process, 12

Galen, 30
Galileo, 28, 36, 56
Genetic engineering, 14, 19, 42
Government, 7, 19, 36
Greek science, 30, 35

Hamlet, 28
Hard science, 40
Heavenly spheres, 31, 51
Heisenberg, W., 37, 42
Heraclitus, 32, 55
Heresy, 22, 24
Hitler, A., 23, 38
Holton, G., 60
Honesty, 36
Hoyle, F., 15, 38
Huxley, A., 19
Hypothesis, 30, 39, 41, 43, 46, 51, 54, 55

I Ching, 27
Iliad, 53
Individualism, 15
Industries, 7
Intrinsic value, 2

Janeway, E., 22
Jaynes, J., 32, 53, 59, 60
Jung, C., 27, 39

Kantrowitz, A., 21, 29
"Knowledge or Certainty", 37
Kohlberg, L., 4, 15, 39
Kuhn, T.S., 33, 34

Lakatos, I., 35
Leonardo da Vinci, 16, 31
Liberal arts, 9
Lobachevsky, N.I., 25
Lobbies, 7, 8
Lucretius, 49

Marijuana, 4
Measurement, 37
Metaphor, 32, 37, 38, 46, 55
Michelson and Morley, 25
Military-industrial complex, 14, 22
Moral imperative, 3, 49
Morality, 3, 13, 39, 47, 50, 57
Morison, R.S., 60

Nader, R., 8, 64
Napalm, 14, 62
Nazis, 19, 36
Negative effects of science and technology, 13
Nelkin, D., 20, 45
Neoplatonism, 28
Newton, I., 31, 52
Nobel, A., 6, 45
Normal science, 33

Occult, 14, 22
Opinions, 24
Organizations, 6, 13, 15
Oxygen, 34

Paradigm, 33
Pauling, L., 45
Phenomena, 26, 28, 32
Phlogiston, 34
Pirsig, R.M., 29, 46, 58, 60
Plato, 47, 51
Poincaré, H., 31
Polls, 18
Pollution, 11, 14, 20, 21
Popper, K., 35
Population, 14, 19
Prayer, 55, 57
Precision, 37
Priestley, J., 34
Proclus, 28
Professionalism, 6, 11, 42, 64
Prohibition, 3, 40
Proxmire, Senator W., 43
Psychology, 53
Ptolemy, 30
Publication, 6, 8, 44
Pure science, 10

Quality, 44, 46
Quantum, 37

Rationality, 30, 32, 38, 46

Ravetz, J.R., 20, 43
Reich, C.A., 14
Relative value, 2
Religion, 4, 49, 55
Religious revelation, 27, 31
Renoir, P.A., 16
Research, 10, 12, 30, 33, 36, 43, 44, 56
Revolutions in science, 30, 60
Riemann, G.F.B., 25
"Romantic" awareness, 46
Romantic movement, 28
Routine science, 10

Schumacher, E.F., 40, 59
Science court, 21, 29
Science organizations, 7
Scientific method, 30, 35, 38
Scientific revolutions, 33, 60
Scholasticism, 28
Shakespeare, W., 28, 31
Simon, S.B., 4
"Simple" science, 6, 63
Slang, 46
Snow, C.P., 29
Soft science, 40
Space, 12, 16
Specialists, 29
St. John's College, 9, 61
Szilard, L., 31, 45

Technicians, 10, 41
Technocrats, 10
Technologists, 10, 41, 42, 57
Technology, 10, 17, 38, 43, 46, 47, 56, 57
Temperance, 3
Theories, 29, 30, 39
Timaeus, 51
Tolerance, 37
Tolstoy, L., 33
Train service, 1
Trippett, F., 21

Ugliness in technology, 14, 16
Uncertainty, 37
Universe, 51

V2 rocket, 38
Variables, 37

Whistle blowers, 15, 18
Witches, 22, 29, 59
Words, 32, 34, 53

Zen, 46, 47

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